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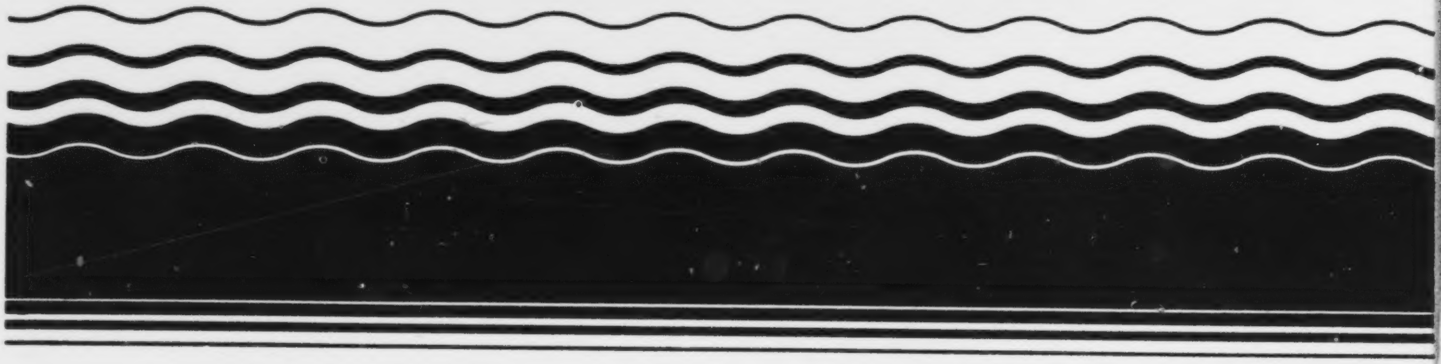

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Guidance for Data Useability in Risk Assessment

Interim Final

Office of Emergency and Remedial Response
U. S. Environmental Protection Agency
Washington, D.C. 20460

The policies and procedures set forth here are intended as guidance to Agency and other government employees. They do not constitute rulemaking by the Agency, and may not be relied on to create a substantive or procedural right enforceable by any other person. The government may take action that is at variance with the policies and procedures in this manual.

Copies of the manual can be obtained by calling EPA's Center for Environmental Research at 513-569-7652 (FTS 684-7652).

PREFACE

The Environmental Protection Agency (EPA) has established a Data Useability Workgroup to develop national guidance for minimum data quality requirements to increase the useability of environmental analytical data in the cleanup of hazardous waste sites under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended in the Superfund Amendments and Reauthorization Act of 1986 (SARA). Data useability is the process of assuring or determining that the quality of data generated meets the intended use. This guidance has been designed by the Workgroup to provide data users with a nationally-consistent basis for making decisions about the minimum quality and quantity of environmental analytical data that are sufficient to support Superfund decisions, regardless of which parties conduct the investigation.

The Data Useability Workgroup is jointly chaired by EPA Region III and the Hazardous Site Evaluation Division (HSED) of the Office of Emergency and Remedial Response (OERR). Membership includes staff from all EPA Regional Offices and from EPA Headquarters Divisions, as well as representatives from the contractor community. The Workgroup's responsibility is to define the current uses and associated data quality requirements and develop minimum requirements for each data use category, including site assessments, risk assessments, and removal and remedy selection for remedial and enforcement actions. Subgroups have been formed to develop detailed guidance manuals on data useability for each data use category. Members of the Risk Assessment Subgroup, responsible for generating this manual, have experience in human health risk assessment, remedial project management, chemistry, toxicology, hydrogeology, and quality assurance.

This guidance manual provides direction for planning and assessing analytical data collection activities for the baseline human health risk assessment, conducted as part of the remedial investigation (RI) process. The guidance does not address the use of environmental data for purposes other than baseline risk assessments for human health. The manual provides guidance on the following:

- How to design RI sampling and analytical activities that meet the data quality and data quantity needs of risk assessors.
- Procedures for assessing the useability of the environmental analytical data obtained in the RI.
- Options for combining data of varying levels of quality from different sources and incorporating them into the risk assessment.
- Procedures for determining the degree of confidence in the risk assessment based on the uncertainty in the environmental analytical data.
- Guidelines for timing and execution of the various activities.
- Appendices requested by risk assessors and RPMs that describe data review summaries, assist in selecting analytical methods to meet required detection limits, and describe data qualifier flags.

The manual complements guidance provided in Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) (RAGS) (EPA 1989a), and Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a), and Data Quality Objectives for Remedial Response Activities (EPA 1987a). While RAGS provides the framework for making data quality assessments in baseline risk assessments, this manual supplements and strengthens important technical details of the framework by providing guidance on minimum requirements for environmental analytical data used in baseline risk assessments. As such, it complements and builds upon Agency guidance for the development and use of data quality objectives in all data collection activities.

This manual is addressed primarily to the Remedial Project Managers (RPMs) who have the principal responsibility for leading the data collection and assessment activities that support the human health risk assessment and secondarily, to risk assessors who must effectively communicate their data needs to RPMs and use the data provided to them. Chemists, quality assurance specialists, statisticians, hydrogeologists and other technical experts involved in the RI process can use this guidance to optimize the useability of data collected in the RI for use in baseline risk assessments.

This manual is being distributed as an interim final document to allow for a period of field testing by RPMs and risk assessors. General comments concerning the usefulness of sections and worksheets should be sent to:

Toxics Integration Branch
Office of Emergency and Remedial Response
401 M Street, SW (OS-230)
Washington, DC 20460
Phone: 202/475-9486

Following the comment period, the manual will be updated and finalized. Further edits may be necessary when data useability manuals for other data uses are completed. Periodically, updates of portions of the manual will be distributed.

GUIDANCE FOR DATA USEABILITY IN RISK ASSESSMENT

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This manual was developed by an EPA workgroup with membership from EPA Headquarters, EPA regional offices and representatives of the contractor community. The EPA Risk Assessment Subgroup of the Data Useability Workgroup provided valuable input regarding the content, approach and organization of the manual. Technical review was provided by professionals who included toxicologists, chemists, quality assurance specialists, engineers, project managers, and statisticians from both EPA and contractor staff.

Leadership was provided by Data Useability Workgroup Region III Co-chairpersons Chuck Sands and Claudia Walters, and Ruth Bleyler of the Toxics Integration Branch (TIB). Members of the Risk Assessment Subgroup include:

Matt Charsky	Office of Waste Programs Enforcement
Richard Brunker	USEPA Region III
Dawn Iovan	USEPA Region III
Pat van Leeuwen	USEPA Region V
Jon Raucher	USEPA Region VI
Cindy Kaleri	USEPA Region VI
Gwen Hooten	USEPA Region VIII
Jim Luey	USEPA Region VIII
Jim LaVelle	USEPA Region VIII
Chris Weis	USEPA Region VIII
Leigh Woodruff	USEPA Region X
Skip Ellis	CH$_2$M HILL
Robin Smith	CH$_2$M HILL
Carla Dempsey	Weston
Dave Bottrell	Viar and Company
Anne Babyak	Viar and Company

Chapter 1
Introduction and Background

Chapter 1 Introduction and Background

- Presents critical data useability issues.
- Specifies audience to be primarily RPMs and risk assessors.
- Defines scope and specifies organization of manual.

ACRONYMS FOR CHAPTER ONE

CLP	Contract Laboratory Program
QA	Quality Assurance
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RI	Remedial Investigation
RPM	Remedial Project Manager

1.0 INTRODUCTION AND BACKGROUND

This manual was developed by the Environmental Protection Agency (EPA) as technical guidance primarily for Remedial Project Managers (RPMs) and risk assessors. The manual is designed to assist RPMs in maximizing the useability of environmental analytical data collected in the Remedial Investigation (RI) process for baseline risk assessments for human health. Since RPMs, with assistance from technical experts, oversee the preparation of work plans and sampling and analysis plans (SAPs) for RI data collection, it is important for them to understand the types, quality and quantity of data needed by risk assessors, and the impact that their data collection decisions have on the level of certainty of baseline risk assessments for human health. The manual provides guidance on the following:

- How to design RI sampling and analytical activities that meet the data quantity and data quality needs of risk assessors.
- Procedures for assessing the quality of the data obtained in the RI.
- Options for combining environmental analytical data of varying levels of quality from different sources and incorporating them into the risk assessment.
- Procedures for determining the level of confidence in the risk assessment based on the uncertainty in the environmental analytical data.
- Guidelines on the timing and execution of the various activities, in order to most efficiently produce deliverables.

Risk assessors should be an integral part of the RI planning process to ensure that adequate environmental analytical data of acceptable quality are collected during the RI. This guidance assists risk assessors in communicating their environmental analytical data needs to RPMs. Risk assessors should work closely with the RPM to identify and recommend sampling designs and analytical methods that will maximize the quality of the baseline risk assessment for human health within the site-related and budgetary constraints of the RI, and will produce consistent risk assessments useful to risk managers.

Although ecological data useability is not addressed specifically in this manual, the chemical data obtained from the site characterization are useable for certain elements of the ecological assessment. However, in an ecological assessment, the chemicals of potential concern and their priorities may be different than those of the human health risk assessment. For example, iron is rarely of concern in human health risk assessments, but high levels of iron may pose a threat to aquatic species.

1.1 Critical data quality issues In risk assessment

The Risk Assessment Subgroup has identified five basic environmental data quality issues that are frequently encountered in risk assessments. This manual provides procedures, minimum requirements, and other guidance to resolve or minimize the effect of these issues on the confidence of the risk assessment. The following sections describe these issues and their impact on data useability, and highlight the resolutions of these issues. The issues affect both the planning for and the assessment of analytical data for use in the RI risk assessments.

1.1.1 DATA SOURCES

Data users must select an analytical source and service appropriate to the data needs of each risk assessment. Practical tradeoffs among detection limits, response time, documentation, analytical costs, and level of uncertainty should be considered prior to selecting sampling designs, analytical methods, and service providers.

The Contract Laboratory Program (CLP) has been the principal source of analytical data for investigations at hazardous waste sites. The CLP requires adherence to specific data acceptance criteria which results in data of known quality produced in a standardized package. Also, CLP costs are not charged directly to the RPM's site account. However, in many cases, other analytical sources, such as field analysis or fixed laboratories (EPA, State, or private), can produce data of acceptable quality at equal or lower cost than the CLP. Accordingly, RPMs and risk assessors should not use the CLP as a default option, but should seek the source of data that best meets the data quality needs of the risk assessment. Section 4.2 of this manual provides guidance for selecting analytical sources.

Field analytical data have been used primarily to aid in making decisions during sampling. However, recent advances in technology, when accompanied by sufficient and appropriate quality control measures, allow field analytical data to be used in risk assessments with more frequency and more confidence than in the past. By using field analyses, RPMs can increase the number of sample numbers to better characterize the site and significantly decrease sample turnaround time to provide real-time decision-making in the field, as long as acceptable data quality is maintained. Guidance for assessing the useability and applicability of field analytical data in the risk assessment process is also provided in Section 4.2.

1.1.2 DETECTION LIMITS

Selecting the analytical method to meet the required detection limits is fundamental to the useability of analytical data in risk assessments. In addition, the type of detection limit such as method detection limit (MDL), or sample quantitation limit (SQL), used in making data quality decisions affects the confidence of the risk assessment. Guidance for making these decisions is provided in Section 4.2 of this manual.

1.1.3 QUALIFIED DATA

Laboratories and individuals conducting independent data review affix coded qualifiers to data when quality control requirements or other evaluation criteria are not met. Qualified data must be appropriately used in risk assessments. Data are almost always useable in the risk assessment process, as long as the uncertainty in the data and its impact on the level of confidence of the risk assessment are thoroughly explained. Section 5.6 describes procedures for incorporating qualified data and data of various qualities into the risk assessment.

1.1.4 BACKGROUND SAMPLES

In conducting a risk assessment, it is critical to distinguish site contamination from background levels due to anthropogenic or naturally-occurring contamination, in order to determine the presence or absence of contamination. Analytical data reported near method detection limits, and sample results qualified during data review, complicate the use of background sample data to determine site contamination. Planning for the collection of a sufficient number of background samples from representative locations increases the confidence in decisions about the presence or absence of site contamination. Section 4.1 discusses how statistical analysis and professional judgment can be combined to design a sampling program for collecting adequate background data.

1.1.5 CONSISTENCY IN DATA COLLECTION

Data collection activities may vary among parties conducting RIs. Consistency in all Superfund activities is increasingly crucial. All parties collecting environmental analytical data for baseline risk assessments for human health must use guidance provided in RAGS (EPA 1989a) and this manual to ensure that baseline risk assessments for human health are conducted consistently and are protective of the public health.

1.2 Framework and Organization of the Manual

This guidance manual is organized following the usual sequence to determine the useability of environmental analytical data used in baseline human health risk assessments. Exhibit 1-1 illustrates the conceptual framework for the manual. Six criteria are defined here to evaluate data useability for baseline risk assessments for human health:

- Data sources.
- Documentation.
- Analytical methods and detection limits.
- Data quality indicators.
- Data review.
- Reports to risk assessor.

These criteria address the five major data quality issues described in Section 1.1 and other issues that impact data useability in the risk assessment. These data useability criteria are applied in RI planning to guide the design of sampling plans and select analytical methods for the data collection effort. The criteria are employed again to assess the useability of the analytical data collected during the RI, and of data from other studies and sources, such as site inspections (SIs). Finally, the manual describes how to determine the degree of confidence in the risk assessment based on the level of uncertainty of the environmental analytical data determined using the data useability criteria.

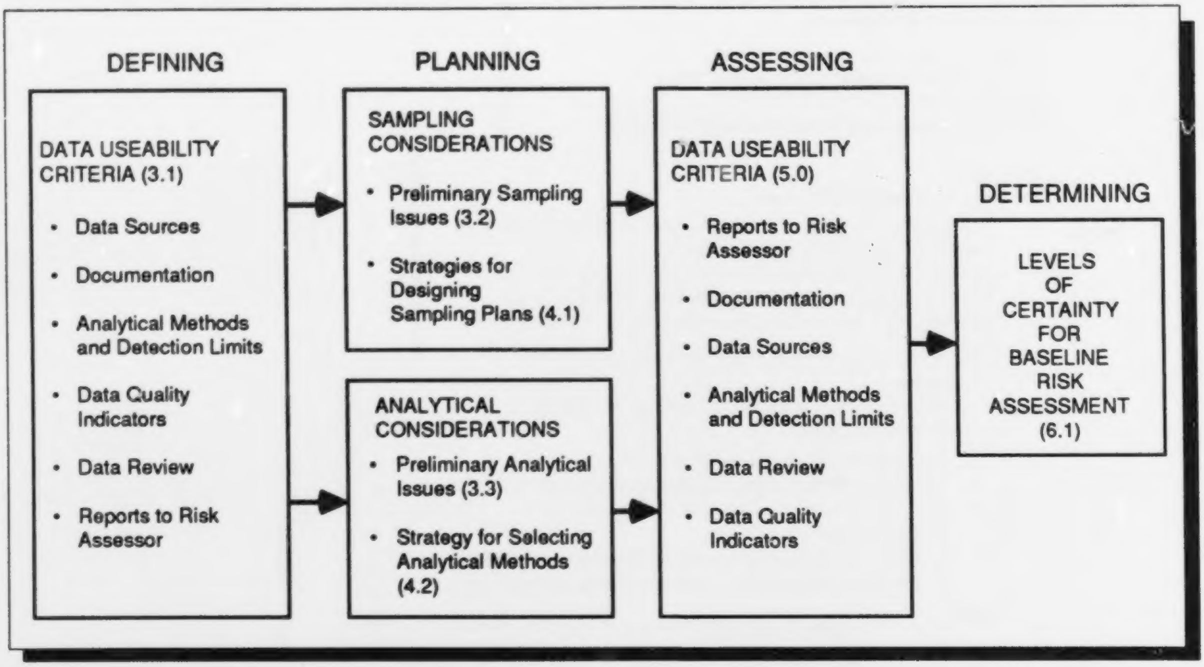
The primary planning objective is that uncertainty levels are acceptable, known and quantifiable, not that uncertainty be eliminated.

Exhibit 1-2 summarizes the purpose of each chapter of this manual and highlights how the chapter can best assist RPMs and risk assessors. Worksheets, assessment tables, and other aids are used extensively throughout the manual. Chapter contents are summarized below:

- Chapter 2 - The Risk Assessment Process: This chapter explains the purpose and objectives of a baseline human health risk assessment and describes the four basic elements of a risk assessment: 1) data collection and evaluation, 2) exposure assessment, 3) toxicological assessment, and 4) risk characterization. The chapter discusses the uncertainties associated with the risk assessment process and emphasizes the impact of analytical data quality on each element. The roles and responsibilities of the RPM, the risk assessor, and others involved in planning and conducting data collection activities to support the risk assessment are described.
- Chapter 3 - Criteria for Evaluating Data Useability in Baseline Risk Assessments: Six criteria are defined in this chapter for interpreting the impact of sample collection, analytical techniques, and data review procedures on the

EXHIBIT 1-1

DATA USEABILITY CRITERIA TO PLAN SAMPLING, ANALYSIS AND ASSESSMENT EFFORTS IN BASELINE RISK ASSESSMENTS


DEFINING
DATA USEABILITY CRITERIA (3.1)
• Data Sources
• Documentation
• Analytical Methods and Detection Limits
• Data Quality Indicators
• Data Review
• Reports to Risk Assessor
PLANNING
SAMPLING CONSIDERATIONS
• Preliminary Sampling Issues (3.2)
• Strategies for Designing Sampling Plans (4.1)
ANALYTICAL CONSIDERATIONS
• Preliminary Analytical Issues (3.3)
• Strategy for Selecting Analytical Methods (4.2)
ASSESSING
DATA USEABILITY CRITERIA (5.0)
• Reports to Risk Assessor
• Documentation
• Data Sources
• Analytical Methods and Detection Limits
• Data Review
• Data Quality Indicators
DETERMINING
LEVELS OF CERTAINTY FOR BASELINE RISK ASSESSMENT (6.1)

useability of analytical data in risk assessments. The sampling and analytical issues that need to be addressed in using these criteria are discussed. The chapter stresses the need to consider and plan for risk assessment data requirements in the early design stages of the RI.

- Chapter 4 - Steps for planning for the Acquisition of Useable Environmental Data in Baseline Risk Assessments: This chapter provides explicit guidance for designing sampling plans and selecting analytical methods based on the data quality requirements of baseline risk assessments. A Sample Design Selection Worksheet and a Method Selection Worksheet are provided as part of the step-by-step guidance for making data collection decisions for individual sites.
- Chapter 5 - Assessment of Environmental Data for Useability in Baseline Risk Assessments: This chapter explains how to assess the useability of site-specific data for risk assessments after data collection, and describes options available to risk assessors for incorporating analytical data from different sources and of various levels of quality into the baseline risk assessment. Data evaluation is presented in assessment phases to address data useability by the six criteria defined in Chapter 3. For each assessment phase, the chapter defines minimum data requirements and explains how to identify performance objectives, determine actual performance compared to objectives, and execute appropriate corrective actions for data critical to the risk assessment.
- Chapter 6 - Application of Data to Risk Assessments: This chapter details procedures for determining the overall level of uncertainty associated with the risk assessment. The discussion addresses characterization of exposure pathways, determining the presence or absence of chemicals of potential concern, and distinguishing site contamination from background levels.
- Appendices - The appendices provide analytical and sampling technical reference materials including: descriptions of generic organic and inorganic data review packages; listings of common pollutants, analytical methods, detection or quantitation limits, and common laboratory contaminants; calculation formulas for statistical evaluation; and information on analytical data qualifiers.

EXHIBIT 1-2

ORGANIZATION OF THE MANUAL

Chapter 1
Introduction and Background

- Presents critical data useability issues.
- Specifies audience to be primarily RPMs and risk assessors.
- Defines scope and specifies organization of manual.

Chapter 2
The Risk Assessment Process

- Explains the elements of a risk assessment and the impact of analytical data quality on each element.
- Defines the uncertainties in the risk assessment process.
- Describes the roles of the risk assessor, RPM and others involved with the risk assessment planning and assessment process.

Chapter 3
Criteria for Evaluating Data Useability in Baseline Risk Assessments

- Defines six criteria for assessing data useability.
- Applies criteria to sampling and analytical issues.

Chapter 4
Steps for Planning for the Acquisition of Useable Environmental Data in Baseline Risk Assessments

- Provides guidelines for designing sampling plans and selecting analytical methods.
- Provides worksheets to support sampling plan design and analytical method selection.

Chapter 5
Assessment of Environmental Data for Useability in Baseline Risk Assessments

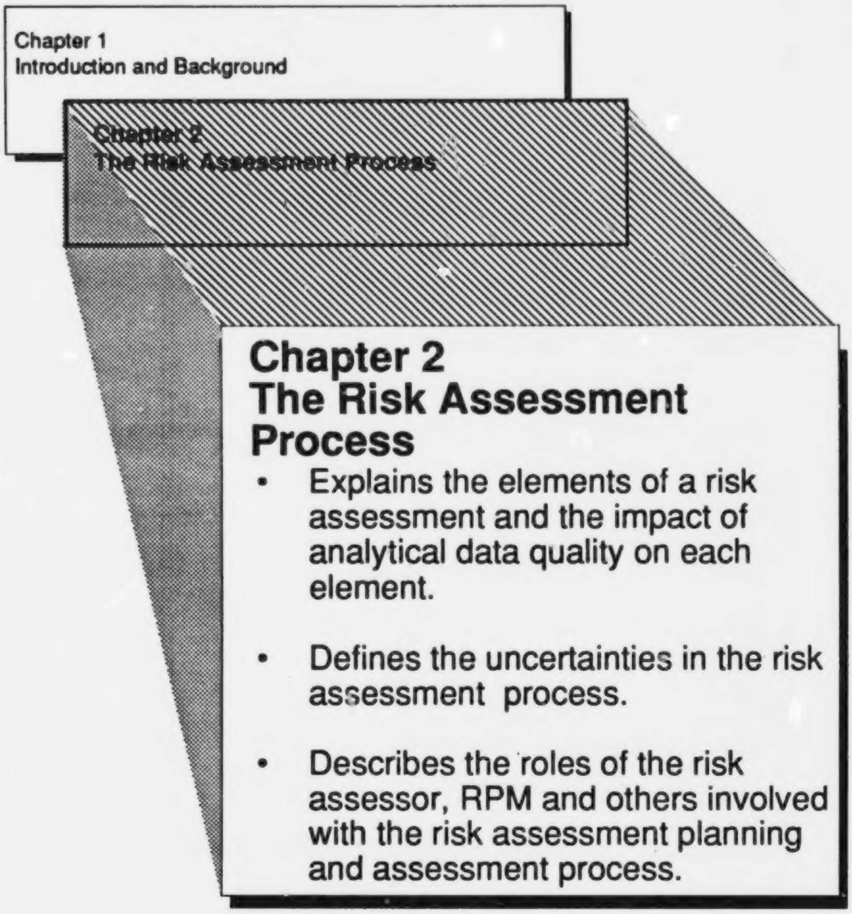
- Describes minimum requirements for useable data.
- Explains how to determine actual performance compared to objectives.
- Recommends corrective actions for critical data not meeting objectives.
- Describes options for combining data from different sources and of varying quality into the risk assessment.

Chapter 6
Application of Data to Risk Assessments

- Provides procedures to determine the uncertainty of the analytical data.
- Explains how to distinguish site from background levels of contamination and determine presence (absence) of contamination.
- Discusses how to characterize exposure pathways.

APPENDICES

- Provide technical reference tables for sampling and analysis.
- Describe data review packages and meanings of selected data qualifiers.



Chapter 1
Introduction and Background

Chapter 2
The Risk Assessment Process

Chapter 2
The Risk Assessment Process

- Explains the elements of a risk assessment and the impact of analytical data quality on each element.

- Defines the uncertainties in the risk assessment process.

- Describes the roles of the risk assessor, RPM and others involved with the risk assessment planning and assessment process.

ACRONYMS FOR CHAPTER TWO

ATSDR	Agency for Toxic Study and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
FS	Feasibility Study
IRIS	Integrated Risk Information System
LOAEL	Lowest-observable-adverse-effects-level
LSI	Listing Site Inspection
NOAEL	No-observable-adverse-effects-level
NPL	National Priorities List
RAGS	Risk Assessment Guidance for Superfund
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RPM	Remedial Project Manager
QA	Quality Assurance
QC	Quality Control
SAP	Sampling and Analysis Plan
UCL	Upper Confidence Limit

2.0 THE RISK ASSESSMENT PROCESS

This chapter presents an overview of the data collection and evaluation issues that affect the quality and useability of baseline human health risk assessments. The discussion focuses on the influence of the quality of environmental analytical data on the level of certainty of the risk assessment, and the importance of an analysis of data limitations in characterizing risks to human health.

The chapter assists Remedial Project Managers (RPMs) and other professionals in planning and conducting RI data collection efforts supportive of the risk assessment process by enhancing their understanding of the data quality needs of risk assessors.

Two main sections comprise this chapter:

- Section 2.1 provides an overview of the baseline human health risk assessment, and discusses the significance of uncertainty in each stage of the risk assessment process.
- Section 2.2 is a summary of the roles and responsibilities of key participants in the risk assessment process.

2.1 Overview of Baseline Human Health Risk Assessment and the Evaluation of Uncertainty

The approach to baseline human health risk assessments of exposure to chemicals of potential concern is well established. The National Research Council (NRC) prepared a comprehensive overview of the structure of this assessment (NRC 1983) that has become the foundation for subsequent EPA guidance (EPA 1986b; EPA 1989a,b). The Risk Assessment Guidance for Superfund (RAGS): Human Health Evaluation Manual Part A (EPA 1989a) provides a detailed presentation of the human health baseline risk assessment for the Superfund Program.

The risk assessment process has four components:

- Data collection and evaluation.
- Exposure assessment.
- Toxicity assessment.
- Risk characterization.

Exhibit 2-1 lists information sought in each component of the baseline risk assessment.

EXHIBIT 2-1

COMPONENTS AND RELATED DATA OF THE RISK ASSESSMENT PROCESS

RISK ASSESSMENT COMPONENT	DATA
Data Collection and Evaluation	Background monitoring data for all affected media. Environmental data for all relevant media. List of chemicals of potential concern. Shape of the distribution of sampling data. Confidence limits surrounding estimates of representative values.
Exposure Assessment	Release rates. Physical, chemical and biological parameters to evaluate transport and transformation of site-related chemicals. Parameters to characterize receptor groups including activity/behavior/sensitivity. Estimates of exposure concentrations for all chemicals, environmental media and receptors at risk. Estimates of chemical intake or dose for all exposure pathways.
Toxicity Assessment	Toxicity measures for all chemicals and exposure pathways of concern. Uncertainty factors and confidence measures for RfDs; weight-of-evidence classifications for cancer slope factors.
Risk Characterization	Hazard quotients and indices. Estimates of excess lifetime cancer risk. Uncertainty analysis.

Uncertainty analysis is often viewed as the last step in the risk characterization process. However, uncertainty analysis is a fundamental element of each of the components of risk assessment, and the results for each component must be presented with an explicit statement of the degree of confidence. These measures are the bases for the estimation of the degree of confidence in the risk assessment. This chapter reviews the issues determining the level of confidence in each component of risk assessment.

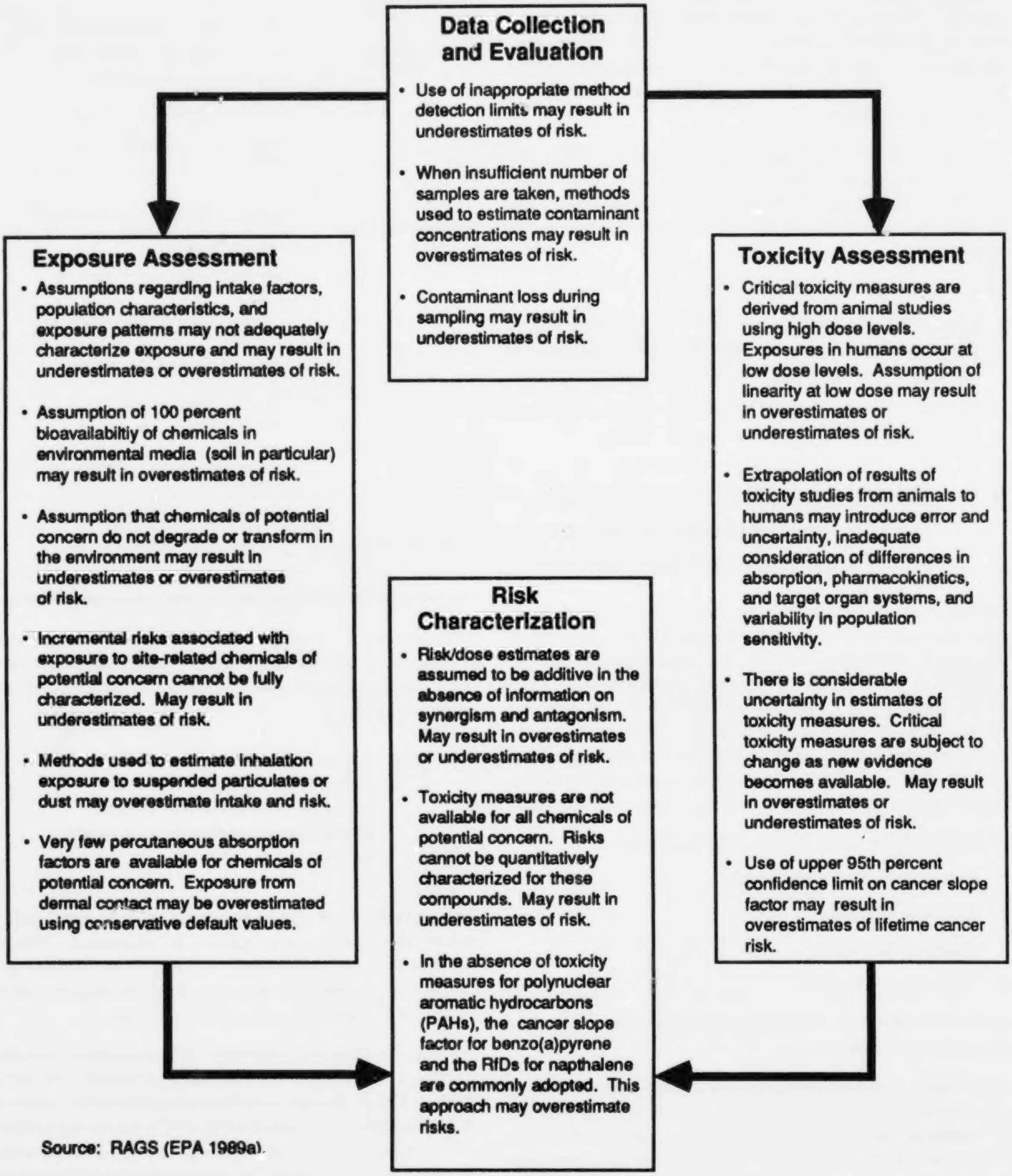
> *The risk assessor must be involved from the start of the RI process to maximize the useability of environmental analytical data for risk assessmentS.*

The importance of obtaining analytical data that fulfill the needs of risk assessment cannot be overstated. The risk assessor must be involved from the start of the risk assessment process to help establish the scope of the investigation and the design of the sampling and analysis program.

All analytical data that result from risk assessment operations must be evaluated for their useability in baseline risk assessments. The procedures used to evaluate the adequacy of the data should be documented along with the resulting estimates of the levels of confidence. Although limitations in the analytical data introduce additional uncertainties and restrict the depth

EXHIBIT 2-2

BASELINE RISK ASSESSMENT PROCESS AND TYPICAL SOURCES OF UNCERTAINTY



Data Collection and Evaluation

- Use of inappropriate method detection limits may result in underestimates of risk.
- When insufficient number of samples are taken, methods used to estimate contaminant concentrations may result in overestimates of risk.
- Contaminant loss during sampling may result in underestimates of risk.

Exposure Assessment

- Assumptions regarding intake factors, population characteristics, and exposure patterns may not adequately characterize exposure and may result in underestimates or overestimates of risk.
- Assumption of 100 percent bioavailabiltiy of chemicals in environmental media (soil in particular) may result in overestimates of risk.
- Assumption that chemicals of potential concern do not degrade or transform in the environment may result in underestimates or overestimates of risk.
- Incremental risks associated with exposure to site-related chemicals of potential concern cannot be fully characterized. May result in underestimates of risk.
- Methods used to estimate inhalation exposure to suspended particulates or dust may overestimate intake and risk.
- Very few percutaneous absorption factors are available for chemicals of potential concern. Exposure from dermal contact may be overestimated using conservative default values.

Toxicity Assessment

- Critical toxicity measures are derived from animal studies using high dose levels. Exposures in humans occur at low dose levels. Assumption of linearity at low dose may result in overestimates or underestimates of risk.
- Extrapolation of results of toxicity studies from animals to humans may introduce error and uncertainty, inadequate consideration of differences in absorption, pharmacokinetics, and target organ systems, and variability in population sensitivity.
- There is considerable uncertainty in estimates of toxicity measures. Critical toxicity measures are subject to change as new evidence becomes available. May result in overestimates or underestimates of risk.
- Use of upper 95th percent confidence limit on cancer slope factor may result in overestimates of lifetime cancer risk.

Risk Characterization

- Risk/dose estimates are assumed to be additive in the absence of information on synergism and antagonism. May result in overestimates or underestimates of risk.
- Toxicity measures are not available for all chemicals of potential concern. Risks cannot be quantitatively characterized for these compounds. May result in underestimates of risk.
- In the absence of toxicity measures for polynuclear aromatic hydrocarbons (PAHs), the cancer slope factor for benzo(a)pyrene and the RfDs for napthalene are commonly adopted. This approach may overestimate risks.

Source: RAGS (EPA 1989a).

and breadth of the evaluation, they are not the only source of uncertainty in risk assessment. Exhibit 2-2 identifies some typical sources of uncertainty inherent in each component of the risk assessment.

Risk assessment procedures cover a continuum from simplified, screening-level assessments, to more comprehensive evaluations requiring a robust data set (one designed to support statistical analyses) with a substantial investment of time and resources. Exhibit 2-3 presents this continuum concept of baseline risk assessment and summarizes the influence of the level of certainty in the analytical data set on the risk assessment. Two columns are shown. The first column defines the range of the analysis from low to high degree of uncertainty. The second column describes the associated data useability and limitations in the risk analysis.

EXHIBIT 2-3

RANGE OF UNCERTAINTY OF RISK ASSESSMENT

RANGE OF ANALYSES	DESCRIPTION/LIMITATIONS
Quantitative Assessment of Risk: Uncertainty minimized, quantified, and explicitly stated. Uncertainty is low.	Risk assessment conducted using well designed, robust data set. Sampling program, based on geostatistical or random design, will support statistical analysis of results. Statistical analysis used to characterize monitoring data. Confidence limits or probability distributions may be developed for all key input variables.
Quantitative Assessment of Risk: Magnitude of uncertainty unknown. No explicit quantitative estimates provided. Qualitative, tabular summary of factors influencing risk estimates may be provided.	Risk assessment conducted using data set of limited quality and size. Data set limited by cost, resource and time constraints. No meaningful statistical analysis can be conducted. Results of risk assessment may be quantified but uncertainty surrounding these measures cannot be quantified. Only a qualitative statement is possible. The majority of baseline risk assessments typically fall within this category.
Qualitative Assessment of Risk: No uncertainty estimate possible. Uncertainty is high.	Risks cannot be quantified due to insufficient monitoring or modeling data. Qualitative statement of risks based on historical information or circumstantial evidence of contaminantion is provided. This evaluation must be considered a preliminary, screening level assessment.

- The first level of analysis in Exhibit 2-3 is a quantitative risk assessment based upon a sampling program that can be statistically analyzed. The assessment explicitly bounds and quantitates the uncertainty in all estimates. This analysis represents an ideal that the risk assessment team strives to attain. The assessment is considered "quantitative" in that numeric estimates are derived for the potential for both adverse noncarcinogenic and carcinogenic effects, and the level of certainty can be quantitated.
- The mid-range of the continuum shown in Exhibit 2-3 is a quantitative assessment based on a limited number of samples or on data that cannot be fully quantitated. The risk characterization may include numeric estimates of excess lifetime cancer risk and the calculation of hazard indices. However, the level of analytical uncertainty surrounding these measures is not quantitated and may be large. Given the limitations of the analytical data, only a qualitative evaluation of the analytical uncertainty is generally feasible. Most baseline risk assessments fall within this category.
- The third level of the continuum is a qualitative assessment of risk. The assessment is qualitative because no numeric measures can be derived to indicate the potential for adverse effects, and the level of certainty cannot be assessed. The risk to human health may be considered only in general terms. The assessment may be based upon limited sources of historical information such as disposal records, circumstantial evidence of contamination, or preliminary site assessment data.

All data can be used in the baseline risk assessment as long as their uncertainties are clearly described.

Risk assessments sometimes must be conducted using data of limited quantity and various quality. When RPMs and other technical experts involved in the RI understand the data and the quality of data required in risk assessments, they are better able to design data collection programs which meet these requirements.

2.1.1 DATA COLLECTION AND EVALUATION

Overview of methods for data collection and evaluation

Data collection begins with a statement of the risk assessment purpose and an understanding of the problems to be addressed for the site under investigation. This involves a review of all available historical data and the development of a conceptual site model (EPA 1989a). Once the conceptual model has been developed and information has been disseminated to project staff, data gaps and requirements for the baseline risk assessment can be identified during scoping. Several key issues should be addressed at this time (Neptune et al. 1990):

- Identify the types of data needed.
- Specify how the data will be used.
- Establish the desired level of certainty for conclusions to be derived from the analytical data.

Carefully designed sampling and analysis programs will minimize the subsequent need to qualify the environmental data during the data assessment phase. The objective of the data collection effort is to produce data that can be used to assess risks to human health with a known degree of confidence.

A complete list of chemicals of potential concern is produced when the analytical data have been collected and evaluated. This list of analytes is the focus of the risk assessment. EPA no longer advocates the selection of "indicator compounds" because this may not accurately the reflect the total risk from exposure to multiple site chemicals of potential concern, nor improve the quality or accuracy of the risk assessment.

Uncertainty in data collection and evaluation

Four principal decisions must be made in the data collection and evaluation phase of the risk assessment:

- Determining the presence and levels of contamination at the site under evaluation.
- Determining if the levels of site contamination differ significantly from background concentrations.
- Evaluating whether the analytical data are adequate to identify and examine exposure pathways.
- Evaluating whether the analytical data are adequate to fully characterize exposure pathways.

These decisions are examined in detail in subsequent chapters in this manual. The discussion in this section introduces the basic concepts.

Determining what contamination is present and at what level

Once the site is suspected to be contaminated and chemicals of potential concern have been identified, the levels of chemical contamination in the affected environmental media must be quantitated in order to derive exposure and intake estimates. Estimates of the site contamination must be produced with explicit descriptions of the degree of confidence associated with the concentration values.

Variability in observed concentration levels is due to both sampling design and laboratory analysis. The key issue in optimizing the useability of data is to understand, minimize, and quantify these uncertainties in the risk assessment.

EPA's objective is to protect human health and the environment. Therefore, the design of remedial investigation programs is intended to minimize two potential errors:

- Not detecting site contamination that is actually present (i.e., false negative values).
- Deriving site concentrations that do not accurately characterize the magnitude of contamination.

Determining if site concentrations differ significantly from background concentrations

A fundamental issue in conducting baseline risk assessments is determining if there is an increased risk to human health and the environment. The ability to answer this question depends on the degree of confidence in determining that the background concentrations are significantly different from the concentrations of the chemicals of potential concern at the site. Generally, this question can be confidently answered only if the design of the sampling program accommodates the collection of both site and background samples and if the selection of analytical methods is appropriate.

Evaluation of the differences between site and background concentrations is conducted by comparing observed levels of chemicals of potential concern at the site with measured background concentrations of the same chemicals in the same environmental media. Statistically, this is a test of the null hypothesis, that the mean concentration of a chemical at the study area is not significantly different from the mean value at the background (or remote uncontaminated) location.

If data from background samples are clearly different from the results of site monitoring (e.g., chemical concentrations differ consistently by two orders of magnitude), statistical analysis of the data may not be necessary. Under such circumstances, RAGS (EPA 1989a) indicates that the primary issue is establishing a reliable representation of the extent of the contaminated area.

The null hypothesis is always evaluated and accepted or rejected with a specified level of certainty. This level of certainty is defined by the significance or confidence level. Type I error is the probability that the null hypothesis is rejected when in fact it is true (i.e., false positives). Type II error is the probability that the null hypothesis is accepted when it is false (i.e., false negatives). The effects of sampling and analysis design on the likelihood of these two types of errors are described in Chapter 4.

Evaluating whether analytical data are adequate to identify and examine exposure pathways

Identifying and delineating exposure pathways is important in identifying potentially exposed populations and in developing intake estimates. In the baseline risk assessment, the risk assessor combines data on the extent of contamination with information on human activity patterns to identify exposure pathways and to examine the exposure area. The ability to accomplish this depends on the adequacy of available analytical data.

Sampling should be designed to provide representative data for exposure areas at a site, to address hot spots, to evaluate the transport of site-related chemicals of potential concern, and to facilitate the identification of all exposure pathways. A well-designed sampling and analysis program will result in data of known quality, quantification of spatial and temporal variability, and specify an approach for interpreting the magnitude of observed values (e.g., comparison with background levels or some other benchmark). The development of a three-dimensional characterization of the extent of contamination at the site is a critical element of this process.

Evaluating whether analytical data are adequate to fully characterize exposure pathways

Heterogeneity should be considered in the environmental medium under evaluation. Hot spots need to be identified and characterized. Neptune et al. (Netune et al. 1990) have proposed the concept of an "exposure unit" as the area over which receptors are projected to integrate exposure. This concept establishes a basis for summarizing the results of monitoring and transport modeling. The sampling and analysis program must be designed to enable the risk assessor to refine the initial characterization of exposure pathways and to spatially and temporally identify the critical areas of exposure.

2.1.2 EXPOSURE ASSESSMENT

Overview of methods for exposure assessment

The objectives of the exposure assessment are to:

- Define exposure pathways.
- Identify potentially exposed populations.
- Measure or estimate the magnitude, duration, and frequency of exposure for each receptor (or receptor group).

Analysis of the first two objectives is particularly important in identifying data needs. Quantitation of the exposure concentration of each chemical of potential concern in each environmental medium, and an assessment of the transport and transformation of the subject compounds are critical to the exposure assessment. These analyses provide essential information on the nature and extent of contamination needed for risk assessment. Typically, the exposure assessment uses both monitoring data and environmental transport models.

Actions at hazardous waste sites are based on an estimate of the reasonable maximum exposure (RME) expected to occur under both current and future conditions of land use (EPA 1989a). EPA defines the RME as the highest exposure that is reasonably expected to occur at a site over time. RMEs are estimated for individual pathways, and combined across exposure pathways if appropriate. Once potentially exposed populations are identified, environmental concentrations at points of exposure must be determined or projected. Intake estimates (in mg/kg-day) are then developed for each chemical of potential concern using a conservative, protective estimate of the concentration contacted by the receptors over the exposure period. The 95 percent upper confidence limit (UCL) on the arithmetic mean environmental concentration is used in developing the RME scenario (EPA 1989a).

In the risk assessment report, estimates of intake must be accompanied by a full description of the assumptions made in their development. In addition, the risk assessor should indicate the range of possible values for each input parameter in the assessment. This information may be used subsequently to conduct sensitivity and uncertainty analysis in the risk characterization.

Uncertainty analysis in exposure assessment

Exposure assessments can introduce large uncertainty into the baseline risk assessment process. The largest measure of uncertainty will be associated with characterizing transport and transformation of chemicals in the environment, establishing exposure settings, and deriving estimates of sub-chronic and chronic intake. The ultimate effect of uncertainty in the exposure assessment is an uncertain estimate of intake.

The following two parts of this sub-section discuss the significance of uncertainty in the analytical data set on selected aspects of exposure assessment. For a complete discussion of the exposure assessment process, the reader is referred to the Superfund Exposure Assessment Manual (SEAM) (EPA 1988c) and RAGS (EPA 1989a).

Characterizing environmental fate, exposure pathways and identifying receptors at risk

An evaluation of the transport and transformation of chemicals in the environment is conducted for several reasons:

- to understand the behavior of site-related chemicals of potential concern.
- to project the ultimate disposition of these chemicals.
- to identify exposure pathways and receptors at risk.
- to characterize environmental concentrations at the point of exposure.

These evaluations cannot be accomplished with any degree of confidence if the analytical data are inadequate.

Environmental fate transport assessment often uses models to estimate concentrations in environmental media at points distant from the source of release. These transport models are commonly selected for their utility in describing or interpreting a set of monitoring data. Chemical transport models must be carefully selected for their ability to meaningfully characterize the behavior of compounds in the environmental medium under investigation. Models that are inappropriate for the geophysical conditions at the site will result in errors in the exposure assessment. For example, the model may be designed to predict contaminant movement through clay while soils at the site are primarily made up of sand. Additionally, if the analytical data set is severely limited in size, or does not accurately characterize the nature of contamination at the site, a transport model cannot be properly selected or calibrated accurately. This will introduce additional uncertainty. Uncertainty in the analytical data, compounded by uncertainty caused by the selection of the transport models may yield results that are meaningless or uninterpretable.

Monitoring data are most appropriately used to estimate current or existing exposure when direct contact with contaminated environmental media is the primary concern. Transport modeling is required, however, in order to evaluate the potential for future exposure, or exposure at a distance from the source of release. In both cases, success in identifying potentially exposed populations depends on the adequacy of the analytical data.

Estimating chemical intake

Uncertainties in all elements of the exposure assessment are brought together and compounded in the estimate of intake. It is here that the professional judgement of the risk assessor becomes particularly important. The risk assessor must examine and interpret a diversity of information:

- The nature, extent and magnitude of contamination.
- Results of environmental transport modeling.
- Identification of exposure pathways.
- Identification of receptor groups currently at risk and potentially at risk in the future.
- Activity patterns and sensitivities of receptors and receptor groups.

Based on this information, the risk assessor must characterize the exposure setting and quantify all parameters needed in the equations to estimate intake (EPA 1989a). Chemical intake is a function of the concentration of the chemical at the point of contact, the amount of contaminated medium contact per unit time or event, the exposure frequency and duration, body weight, and the average period during which exposure occurs. Exhibit 2-4 is the generic form of the intake equation used in exposure assessment.

EXHIBIT 2-4

GENERIC EQUATION FOR CALCULATING CHEMICAL INTAKES

$$I = C \times \left(\frac{CR \times EFD}{BW} \right) \times \frac{1}{AT}$$

Where:

I = intake; the amount of chemical at the exchange boundary (mg/kg body weight-day)

Chemical-related variable

C = chemical concentration; the average concentration contacted over the exposure period (e.g., mg/liter water)

Variables that describe the exposed population

CR = contact rate; the amount of contaminated medium contacted per unit time or event (e.g., liters/day)

EFD = exposure frequency and duration; describes how long and how often exposure occurs. Often calculated using two terms (EF and ED):

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight; the average body weight over the exposure period (kg)

Assessment-determined variable

AT = averaging time; period over which exposure is averaged (days)

Source: RAGS (EPA 1989a).

The specific form of the intake equation will vary depending upon the exposure pathway under consideration, e.g., ingestion, inhalation, dermal contact (EPA 1989a). For the purpose of quantitating intake, each of the variables in these equations, including chemical concentration, are commonly characterized as point estimates. However, each intake variable in the equation has a range of possible values. Site-specific characteristics determine the selection of the most appropriate values. EPA is currently establishing standardized exposure parameters to decrease the variability in the exposure assessment. These standard factors may be used when site-specific data are unavailable. Intake values should be selected so that the combination of all values result in an estimate of reasonable maximum exposure for that pathway (EPA 1989a).

The recommended approach to uncertainty analysis in exposure assessment is to explicitly present the range of observed values for chemicals in the environment and the factors used in developing intake estimates (EPA 1989a). A summary of major assumptions and the anticipated effects on final exposure estimates is then developed. This provides a qualitative but helpful characterization of the level of confidence in the intake estimates.

2.1.3 TOXICITY ASSESSMENT

Overview of methods for toxicity assessment

The objectives of the toxicity assessment are to evaluate the inherent toxicity of the compounds under investigation, and to identify and select toxicological measures for use in evaluating the significance of the exposure. Toxicity assessments conducted under the Superfund program rely on scientific data available in the literature on adverse effects in humans and nonhuman species used to identify toxicity measures for use in risk assessment.

Several important measures of toxicity are needed in conducting an assessment of risk to human health. Reference doses (RfDs) are used for oral and inhalation exposure to evaluate non-carcinogenic and developmental effects and cancer slope factors are used for the oral and inhalation pathways for carcinogens.

RfDs are measures verified by EPA to evaluate the potential for non-carcinogenic effects. The RfD is defined as an estimate (with uncertainty spanning an order of magnitude or more) of a daily exposure level for human populations, including sensitive sub-populations, that is likely to be without an appreciable risk of adverse effect over the period of exposure (EPA 1989a). These measures are derived from no-observable-adverse-effects levels (NOAELs) or lowest-observable-adverse-effects levels (LOAELs) and the application of uncertainty and modifying factors (EPA 1989a). Uncertainty factors are used to account for the variation in sensitivity of human sub-populations and the uncertainty inherent in extrapolation of the results of animal studies to humans. Modifying factors account for additional uncertainties in the studies used to derive the NOAEL or LOAEL.

Cancer slope factors are defined as plausible, upper-bound estimates of the probability of cancer response in an exposed individual, per unit intake over a lifetime exposure period (EPA 1989a). For carcinogenic compounds, EPA assigns a weight-of-evidence rating that reflects the likelihood that the toxicant is a human carcinogen. EPA commonly develops slope factors for carcinogens with weight-of-evidence classifications (EPA 1989a).

To reduce variability in toxicological values used for risk assessment, a standardized hierarchy of available toxicological data is specified for Superfund. The primary source of information for these data is the Integrated Risk Information System (IRIS) database. IRIS consists of verified RfDs and cancer slope factors, and health risk and EPA regulatory information. Data in IRIS are regularly reviewed and updated. If toxicity measures are not available in IRIS, the EPA Health Effects Assessment Summary Tables (HEAST) (EPA 1990c) are used as a secondary current source of information. Additional sources of toxicity information are provided in RAGS (EPA 1989a).

Toxicity evaluations commonly consider lethal and sublethal effects following short-term or long-term exposure. The toxicity measures typically used include the following (EPA 1989b):

- LD50 or LC50 - the administered dose or environmental concentration resulting in mortality in 50 percent of the exposed organisms
- ED50 or EC50 - the administered dose or environmental concentration resulting in nonlethal physiological or behavioral effects in 50 percent of the exposed organisms
- NOEL/NOAEL - threshold levels below which an effect is not observed
- LOEL/LOAEL - the lowest recorded dose at which effects were observed.

The toxicity assessment is conducted in parallel with the exposure assessment, but may begin as early as the data collection and evaluation phase. As chemicals of potential concern are identified at the site, the project toxicologist begins to identify the toxicity measures. A well designed sampling and analysis program will facilitate timely identification of those chemicals that will be the focus of the risk assessment.

Uncertainty analysis and toxicity assessment

Toxicity assessment is another contributor to uncertainty in risk assessment. Limitations in the analytical data from environmental samples affect the results of the toxicity assessment, but not to the extent that they affect other components of the Superfund risk assessment process. Their principal influence is on the ability to comprehensively identify, select, and develop toxicity measures needed in risk characterization. The selection of appropriate toxicity measures is influenced by monitoring data from environmental samples to the extent that this information assists in identifying chemicals of potential concern, exposure pathways, and the time periods over which exposure may occur. Based on this information, the project toxicologist will identify sub-chronic or chronic RfDs and cancer slope factors for oral and inhalation pathways.

In preparing a list of toxicity measures for risk assessment, it is important to provide an indication of the degree of confidence associated with these values. Weight-of-evidence classifications should be included in the discussion of cancer slope factors. Uncertainty and modifying factors used in deriving RfDs from NOAELs or LOAELs should be included in the discussion of non-carcinogenic effects.

2.1.4 RISK CHARACTERIZATION

Overview of methods for risk characterization

The last step in the baseline risk assessment is risk characterization. This is the process of integrating the results of the exposure and toxicity assessments, i.e., comparing estimates of intake with appropriate toxicological measures to determine the likelihood of adverse effects in potentially exposed populations. Risk characterization is considered separately for carcinogenic and non-carcinogenic effects because organisms typically respond differently following exposure to carcinogenic and non-carcinogenic agents. For non-carcinogenic effects, toxicologists recognize the existence of a threshold of exposure below which there is likely to be no appreciable risk of adverse health impacts in an exposed individual. It is the current EPA position that exposure to any level of carcinogenic compounds is considered to carry a risk of adverse effect, and that exposure is not characterized by the existence of a threshold.

The procedure for calculating risk from exposure to carcinogenic compounds has been established by EPA (EPA 1986b, EPA 1989a,b). A non-threshold, dose-response model is used to calculate a cancer slope factor (mathematically, the slope of the dose-response curve) for each chemical. The cancer slope factor is used in conjunction with the chronic daily intake to derive a probabilistic estimate of excess lifetime cancer risk to the individual.

A linearized multistage dose-response model is most commonly used by EPA in deriving the cancer slope estimates. The mathematical relationship used in cancer risk estimates assumes that the dose-response relationship is linear in the low-dose portion of the multistage model dose-response curve (EPA 1989a). Given this assumption, the slope factor is a constant, and risk is directly proportional to intake.

The recommended practice for evaluating the potential for non-carcinogenic effects is to compare the RfD to the intake experienced by the potentially exposed population (EPA 1989a). This ratio (intake/RfD) is termed the "hazard quotient." It is not a probabilistic estimate of risk, but simply a measure of concern, or an indicator of the potential for adverse effects. A more detailed discussion of risk characterization is presented in RAGS (EPA 1989a). For further discussion of methods for risk characterization of environmental or ecological effects, refer to the references (ORNL 1982, 1986; EPA 1988f, 1989b,f).

Uncertainty analysis in risk characterization

No risk assessment is certain. Risk assessment is a process that provides a best estimate of potential (present and future) risk along with the limitations or uncertainties associated with the estimates. The most obvious effect of limitations in the analytical data on risk characterization is the ability to accurately project the potential for adverse effects in potentially exposed individuals. This includes estimates of excess lifetime cancer risk and the potential for adverse non-carcinogenic effects in humans. Clearly, if the available monitoring data do not facilitate a meaningful determination of reasonable maximum exposure values, the risk estimates will directly reflect this uncertainty.

Uncertainties in toxicological measures and exposure assessment are greater than uncertainties in environmental analytical data and usually have a more significant effect on the uncertainty of the risk assessment.

Baseline risk assessments may be conducted using data of widely varying quality. Resource and time constraints often limit the opportunity to develop a well-designed and comprehensive data set. Nonetheless, risk assessments must be conducted using the available information even when there is no opportunity to improve the data set. However, the results should be presented with an explicit statement regarding limitations and uncertainty.

If possible, a sensitivity analysis should be conducted to bound the results of risk assessments. A simple approach might consist of establishing the range of potential values (e.g., minimum, most likely, and maximum) for key input variables and discussing the influence on the resultant level of uncertainty in the risk estimates. The key variables can then be ranked with respect to the magnitude of potential effect on the risk estimates. More quantitative approaches to uncertainty analysis are desirable if they can be supported by the available information. Combining probability distributions using Monte Carlo techniques is one commonly-cited example (EPA 1988c, 1989a, Finkel 1990). An overview of recommended methods for assessment of uncertainty in risk characterization is presented in the Superfund Exposure Assessment Manual (SEAM) (EPA 1988c) and RAGS (EPA 1989a). A more detailed consideration of uncertainty analysis in risk assessment may be found in Methodology for Characterization of Uncertainty in Exposure Assessment (EPA 1985) and Confronting Uncertainty in Risk Management: A Guide for Decision-Makers (Finkel 1990).

2.2 Roles and Responsibilities of Key Risk Assessment Personnel

The risk assessor generally conducts the risk assessment with participation from individuals with specific skills and technical expertise. The quality and utility of the baseline risk assessment will ultimately depend on the planning and interaction of these technical professionals. Key participants include the remedial project manager (RPM) and the risk assessor, who are primarily responsible for ensuring that data collected during the RI are useable for risk assessment activities. Other participants include hydrogeologists, chemists, statisticians, quality assurance staff, and other technical support personnel involved in planning and conducting the RI. Exhibit 2-5 summarizes the roles and responsibilities of the risk assessment participants.

EXHIBIT 2-5

ROLES AND RESPONSIBILITIES OF RISK ASSESSMENT TEAM MEMBERS

INDIVIDUAL	ROLE/RESPONSIBILITY
Remedial Project Manager	• Directs, coordinates and monitors all activities. • Establishes network with other data users including federal, state and local agencies. • Gathers existing site data. • Organizes scoping meeting. • Controls budget and schedule. • Guides preparation of QA documents. • Ensures that risk assessor receives preliminary analytical data. • Contributes to data assessment. • Resolves problems affecting RI objectives including risk assessment issues (e.g., re-sampling, re-analysis).
Risk Assessor	• Reviews all relevant existing site data. • Develops preliminary list of chemicals of potential concern and conceptual site model. • Recommends sample design, analytical requirements including chemicals of potential concern, detection limits and quality control needs during project scoping. • Communicates frequently with RPM, hydrogeologist and chemist to ensure that data collected meet needs. • Reviews and contributes to SAP and QA documents. • Assesses preliminary data as soon as available to verify conceptual site model and assess data quality. • Recommends corrective action (e.g., resampling, reanalysis). • Assesses reviewed data for useability in risk assessment. • Prepares risk assessment.
Hydrogeologist, chemist and other technical support	• Provides technical input to scoping. • Prepares/provides input to SAP and QA documents in support of risk assessment data needs. • Communicates frequently with risk assessor on status of data collection and issues affecting data. • Provides preliminary data for review by risk assessor. • Supports fate and transport modeling for the exposure assessment. • Implements corrective actions to improve data useability.
Quality Assurance Specialist	• Supports preparation of QA documents. • Provides QA data or recommendations for appropriate QC. • Reviews data for quality.

2.2.1 PROJECT COORDINATION

All data collection activities that support the risk assessment are coordinated by the RPM. The RPM's responsibilities begin upon site listing and continue through deletion of the site from the National Priority List (NPL). A network of technical experts, including representatives of other agencies involved in human health or environmental assessments or related issues, is established at the start of the RI. This ensures that the potential for adverse effects to human health and the environment is adequately assessed during the RI. To successfully plan and direct the sampling and analysis effort, the RPM must facilitate the interaction of the key participants.

2.2.2 GATHERING EXISTING SITE DATA AND DEVELOPING THE CONCEPTUAL MODEL

The RPM should ensure that a broad spectrum analysis was conducted at the site for all media and should review industry-specific records to minimize the potential for false negatives. A preliminary list of the chemicals of potential concern is prepared to assist in scoping and developing the conceptual model of the site. The evaluation of the existing site data is an important element in planning the scope of the risk assessment. The RPM is responsible for gathering historical site data for use during the scoping process. Sources of information especially pertinent for risk assessment include: data from potentially responsible parties (PRPs), industrial records including chemicals used in processes, preliminary natural resource studies, ATSDR health studies, Environmental Impact Statements, aerial photographs, site records, listing site inspection (LSI) documentation and site visits.

EXHIBIT 2-6

EXAMPLE RISK ASSESSMENT CHECKLIST FOR USE IN SCOPING

- Has all historical information been gathered and characterized and is it ready to be used?
- What sample matrices should be investigated?
- What analytical methods should be used?
- Are the methods appropriate for risk assessment?
- Will any special quality control requirements be necessary?
- Who will conduct the analysis?
- What analytical data sources should be used (fixed laboratory and/or field analysis)?
- What sampling designs are appropriate?
- How will the data review be accomplished?
- What types of deliverables will be required?
- What budget or other limitations constrain data collection?
- How many background samples will be needed?
- How can the health concerns of state and local agencies best be considered?

The conceptual model is a depiction and discussion of the current understanding of the contamination, the sources of release to the environment, transport pathways, exposure pathways and receptors at risk. Preliminary identification of potential exposure pathways at the site under investigation is particularly important for the design of a thorough data collection effort. The conceptual site model should be provided to all key participants in the remedial investigation during the project scoping and be included in the workplan.

2.2.3 PROJECT SCOPING

The adequacy of the sampling and analysis effort determines the quality of the risk assessment. Therefore, it is imperative that the risk assessor be an active member of RI planning and continue their involvement during the entire course of the project.

Analytical data collected solely for other purposes may not be of optimal use to the risk assessment.

Data obtained solely with the aim of characterizing the nature and extent of contamination at a site may not fully support the needs of the risk assessor in quantifying the potential for adverse effects in human and nonhuman receptors. Information collected only with this regard may result in rejection of the risk assessment or in the need for an additional round of sampling. Therefore, it is important to maintain the risk assessment data requirements as a high priority throughout remedial investigations.

Sampling and analysis methods discussed during scoping should ultimately be based on site-specific data needs. The RPM, risk assessor, hydrogeologist, statistician, and project chemist must maintain open communication during scoping and throughout the RI to ensure that this occurs. Data review and deliverable requirements should be determined during the scoping meetings so that these specifications can be included in the sampling and analysis plan (SAP) for the RI. A checklist of considerations for the scoping meetings should be prepared and provided to all individuals involved. Exhibit 2-6 presents an example checklist of items to be considered during scoping. Chapters 3 and 4 of this manual give specific guidance for planning the data collection efforts to support risk assessments.

2.2.4 QUALITY ASSURANCE DOCUMENT PREPARATION AND REVIEW

Following scoping, the RPM is responsible for guiding the preparation of the workplan and quality assurance documents. The workplan, the SAP and Quality Assurance Project Plan (QAPjP) should document the combined decisions of the RPM, risk assessor, and other project staff. Particular emphasis is placed on establishing confidence limits, acceptable error, and level of quality control. This facilitates cost-effective design of the sampling and analytical program and minimizes the collection of data of limited use for risk assessment.

The risk assessor reviews the workplan and SAP to ensure that the relevant data quality issues, sampling design, analytical needs, and data assessment procedures are adequately addressed. Exhibits 2-7 and 2-8 provide checklists to aid the review of the workplan and SAP.

EXHIBIT 2-7

CHECKLIST FOR REVIEWING THE WORKPLAN

- Does the workplan address the objectives of baseline risk assessment?
- Does the workplan document the current understanding of site history and the physical setting?
- Have historical data been gathered and assessed?
- Has information on probable background concentrations been obtained?
- Does the workplan provide a conceptual site model for the baseline risk assessment, including a summary of the nature and extent of contamination, exposure pathways of potential concern, and a preliminary assessment of potential risks to human health and the environment?
- Does the workplan document the decisions and evaluations made during project scoping, including specific sampling and analysis requirements for risk assessment?
- Does the workplan address all data requirements for the baseline risk assessment and explicitly describe the sampling, analysis and data review tasks?

EXHIBIT 2-8

CHECKLIST FOR REVIEWING THE SAMPLING AND ANALYSIS PLAN

- Do the objectives of the quality assurance project plan (QAPjP) and the field sampling plan (FSP) meet risk assessment needs established in the scoping meeting?
- Are QA/QC procedures provided for in the sampling and analysis plan and are they adequate for the purposes of the baseline risk assessment?
- Have the data gaps for risk assessment that were identified in the RI workplan been adequately addressed in the sampling and analysis plan?
- Are there sufficient quality control samples to measure the likelihood of false negatives and false positives, and to determine the precision and accuracy of resulting data?
- Have analytical methods been selected that have detection limits adequate to quantify compounds at the concentration of concern?
- Have SOPs been prepared for sampling, analysis and data review?
- Will the sampling and analysis program result in the data needed for the baseline risk assessment to:
    - address each medium, exposure pathway and chemical of potential concern;
    - evaluate background concentrations;
    - provide detail on sample locations, sampling frequency, statistical design and analysis;
    - evaluate temporal as well as spatial variation; and
    - support evaluation of current as well as future resource uses?

2.2.5 BUDGETING AND SCHEDULING

As the overall site manager, the RPM must support the many components of the RI. The RPM must address and balance risk assessment data needs with other data use needs such as health and safety, treatability studies, transport, and the nature and extent of contamination. The risk assessor is responsible for identifying specific data requirements for risk assessment and communicating these needs to the RPM. The RPM is responsible for developing and implementing the schedule for the acquisition of the data. Balancing costs and services while adhering to schedule is a major responsibility of the RPM.

The RPM must coordinate the use of analytical services. Data from different analytical sources provide the flexibility needed to balance cost with sampling needs and time constraints. The advantages and disadvantages of field analyses and fixed laboratory analyses should be considered, as described in Chapters 3 and 4 of this manual. The risk assessment participants can assist in the development of field sampling plans and the selection of appropriate analytical methods that will provide the risk assessor with a set of useable data, within the budgeting and scheduling constraints of the RPM.

2.2.6 ITERATIVE COMMUNICATION

Continuing, open, and frequent communication among the participants is critical to the success of the remedial investigation and baseline risk assessment. A single meeting or discussion is rarely adequate to ensure that all relevant issues have been addressed. The development of the risk assessment within the remedial investigation report is an iterative process of action, feedback and correction or adjustment.

After review of the workplan, the SAP and the QAPjP, the RPM should monitor the flow of information. The risk assessor should assist the RPM to ensure that the data produced are in compliance with the requirements of the workplan and SAP. Key questions to be considered once the data become available are:

- Have correct sampling protocols been followed?
- Have all critical samples been collected?
- Have the samples been analyzed as requested?
- Are data arriving in a timely fashion?
- Has quality assurance been addressed as stated in the SAP and QAPjP?
- Have the data been reviewed as stated in the SAP?
- Is the quality of the analytical data acceptable for their intended use?

Based upon these considerations, the RPM and risk assessor must jointly determine if any corrective actions are needed, such as requesting additional sampling, using alternative analytical methods or reanalyzing samples.

2.2.7 DATA ASSESSMENT

The RPM and risk assessor should work with other participants to identify a list of chemicals of potential concern and decide on data review procedures. This information should be developed during project scoping and incorporated into the workplan and SAP. The RPM, risk assessor, and project chemist should be in agreement regarding the type and levels of data review required. Typically, the RPM will assess the data reviewed by the chemist unless other arrangements have been established and explicitly stated in the SAP.

The risk assessor may request preliminary data, or results that have received only a partial review, in order to expedite the risk assessment to save time and resources. However, preliminary data should not be used in calculating risk. Once the full analytical data set is obtained, the RPM and risk assessor should consult with the project chemist and statistician to assess the utility of all available information.

2.2.8 ASSESSMENT AND PRESENTATION OF ENVIRONMENTAL ANALYTICAL DATA

Once the environmental data are evaluated in the data review process, the risk assessor develops a final data set for use in the baseline risk assessment. All chemicals of potential concern should now be identified. The risk assessor should prepare summary tables containing the following information:

- Site name and sample locations.
- Number of samples per medium.
- Analyte-specific sample quantitation limits.
- Number of values above the quantitation limit.
- Measures of central tendency: 95 percent upper confidence limit on the arithmetic mean of the environmental concentration.
- Specifications for the treatment of detection or quantitation limits and treatment of qualified data.
- Ranges of concentrations.

All assumptions, qualifications, and limitations should be explicitly stated on the tables. The final data summary tables should be provided for review to the RPM, project hydrogeologist, project chemist and other appropriate project staff. These are the data that will be used in the baseline risk assessment to determine the potential risk to human health. It is essential, therefore, that this information consists of the best data available and reflects the collective review of the key participants in the risk assessment.

Chapter 1
Introduction and Background

Chapter 2
The Risk Assessment Process

Chapter 3
Criteria for Evaluating Data Useability
in Baseline Risk Assessments

Chapter 3
Criteria for Evaluating Data Useability in Baseline Risk Assessments

- Defines six criteria for assessing data useability.
- Applies criteria to sampling and analytical issues.

ACRONYMS FOR CHAPTER THREE

AA	Atomic Absorption Spectroscopy
ARAR	Applicable or Relevant and Appropriate Requirement
CLP	Contract Laboratory Program
DL	Detection Limit
DQO	Data Quality Objective
ESD	Environmental Services Division
GC	Gas Chromatography
HRS	Hazard Ranking System
ICP	Inductively Coupled Plasma Atomic Emission Spectroscopy
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CV	Coefficient of Variation
ECD	Electron Capture Detector
ID	Instrument Detection Limit
LOL	Limit of Linearity
LOQ	Limit of Quantitation
LSC	Library Search Compound
LSI	Listing Site Inspection
MDL	Method Detection Limit
MS	Mass Spectrometry
NPL	National Priorities List
PA/SI	Preliminary Assessment/Site Inspection
PAH	Polychlorinated Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PRP	Potentially Responsible Party
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SQL	Sample Quantitation Limit
TIC	Tentatively Identified Compound
TRIS	Toxic Release Inventory System

3.0 CRITERIA FOR EVALUATING DATA USEABILITY IN BASELINE RISK ASSESSMENTS

This chapter assists RPMs and risk assessors in applying data useability criteria to plan data collection efforts to maximize the useability of environmental analytical data in baseline risk assessments, and addresses preliminary issues in planning sampling and analysis programs. The chapter provides the background information necessary to conduct strategic planning for the acquisition of environmental data for baseline risk assessments. The quality of a risk assessment is intimately tied to the adequacy of the sampling and analysis plan (SAP) developed during the remedial investigation.

Planning improves the useability of environmental analytical data in the final risk assessment.

Data needs for baseline risk assessments may differ from those for identifying the nature and extent of contamination at a Superfund site. Data collected from planning that is solely aimed at this second purpose may be inadequate for the risk assessment and an additional round of sampling to support the risk assessment may be required. Accordingly, the risk assessor should be an active member of the team planning the Remedial Investigation (RI) and must be consulted from the start of the planning process.

Four fundamental decisions for risk assessment are to be made with the data acquired during the RI, as discussed in Chapter 2. Exhibit 3-1 presents these decisions, lists the criteria or planning issues affecting them, and refers to sections of this manual for related discussions.

- If the sample design is representative, the question of what contamination is present and at what concentration is an analytical problem. Key concerns are the probability of false negatives and false positives. The selection of analytical methods, laboratory performance, and type and amount of data review affects these issues for both site and background samples.
- Assuming that chemicals of potential concern have been identified, the second question involves background levels of contamination. Are site concentrations sufficiently elevated from background levels to support an evaluation of increased risk for human health due to site contamination?
- All exposure pathways must be identified and exposure pathways examined. The two decisions concerning exposure pathways primarily involve the identification and sampling of media of concern.
- The final decision involves the characterization of exposure pathways. Sampling must be representative and satisfy

EXHIBIT 3-1

RELEVANCE OF DATA QUALITY CRITERIA AND PLANNING ISSUES TO RISK ASSESSMENT DECISIONS TO BE MADE WITH ENVIRONMENTAL DATA

Decisions to be Made with Environmental Data	Criteria or Planning Issue(s)	Section
What Contamination is Present and at What Levels?	• Data Review	3.1.5
	• Chemicals of Potential Concern	3.2.1, 3.3.1
	• Library Search Compounds (LSCs)	3.3.2
	• Identification and Quantitation	3.3.3
	• Detection Limits	3.3.4
	• Media Variability	3.3.5
	• Sample Preparation	3.3.6
	• Fixed Laboratory vs. Field Methods	3.3.7
	• Specifying Contaminant Characteristics	4.1 Step II
	• Measurement Error	4.1 Step III D
	• Strategy for Selecting Analytical Methods	4.2
	• Completing the Method Selection Worksheet	4.2.1
	• Evaluating Routine Methods	4.2.2
	• Developing Alternative Methods	4.2.3
	• Selecting Analytical Laboratories	4.2.4
Are Site Concentrations Sufficiently Different From Background?	• Acceptable Limits for Confidence, Power, and Minimum Detectable Relative Difference	4.1 Step III A-C
	• Determining Number of Background Samples	4.1 Step IV C
Are All Exposure Pathways Identified and Examined?	• Data Sources	3.1.1
	• Documentation	3.1.2
	• Media Variability	3.2.3
	• Identification of Exposure Pathways	3.2.5
	• Comparability with Previous Sample Designs	4.1 Step V B
Are All Exposure Pathways Fully Characterized?	• Analytical Methods and Detection Limits	3.1.3
	• Data Quality Indicators	3.1.4
	• Sampling Variability vs. Measurement Error	3.2.2
	• Sample Preparation and Sample Preservation	3.2.4
	• Use of Judgmental or Purposive Sample Design	3.2.6
	• Strategies for Designing Sampling Plans	4.1
	• Identifying Sample Design Alternatives	4.1 Step I
	• Selecting Performance Measures	4.1 Step III
	• Determining Hot Spots	4.1 Step V A
	• Resource Issues	4.1 Step V C

performance objectives determined during the planning process. However, analysis also must be representative, and a broad spectrum analysis must be available to characterize the pathways.

A principal objective of the RI is to collect useable environmental analytical data to enable the risk assessor to make these decisions. RI planning and implementation of RI plans affect the certainty of chemical identification and quantitation. Therefore, these four decisions should be kept in mind throughout the RI.

The chapter is organized into three sections which define the data useability criteria and explains how to apply the criteria to

EXHIBIT 3-2

IMPACT OF DATA USEABILITY CRITERIA IN PLANNING FOR THE BASELINE RISK ASSESSMENT

DATA USEABILITY CRITERION	IMPORTANCE	SUGGESTED ACTION
Data Sources (3.1.1)	Data sources must be comparable if data are combined for quantitative use in risk assessment. Plans can be made in the RI for use of most appropriate data sources so that issues of data compatibility are not encountered.	Data from different data sources can be used together to balance turnaround time, quality of data, and cost. Consultation with a chemist or statistician may be needed to ensure compatibility of data sets.
Documentation (3.1.2)	Deviations from the sampling and analysis plan (SAP) and standard operating procedures (SOPs) must be documented so that the risk assessor will be aware of limitations in the data. The risk assessor may need additional documentation, such as field records on weather conditions, physical parameters and site-specific geology. Field records will impact the useability of some data. Data useable for risk assessment must be identified with a specific location.	Review the workplan and SAP and, if appropriate, SOPs. As the data arrive, check for adherence to the SAP so that corrective action such as re-sampling may be taken and still adhere to the project timetable. Stress importance of chain-of-custody for sample point identification in RI planning meetings.
Analytical Methods/ Detection Limits (3.1.3)	The method chosen must assay for the chemical of potential concern. The choice of method involves planning for a detection limit that will meet the concentration levels of concern. If the detection limit is not low enough to confirm the presence and amount of contamination, samples will have to be re-analyzed at a lower detection limit if possible.	Participate in selecting methods with appropriate detection limits during RI planning. Consultation with a chemist is required when a method's detection limits are near or above concentration levels of concern.
Data Quality Indicators (3.1.4)		
Completeness	Completeness for critical samples must be 100%. Unforeseen problems during sample collection and analysis can affect data completeness. If a sample data set for risk assessment is not complete, more samples may have to be analyzed, affecting RI time and resource constraints.	Completeness should be defined in the sample design for both the number of samples and quantity of useable data needed to meet performance objectives. Critical samples need to be identified during scoping.
Comparability	The risk levels generated in the quantitiative risk assessment will be questionable if incompatible data sets are used together.	Planning for use of comparable methods, sufficient quality control, and common units of measure for different data sets that will be used together will facilitate data comparability. Consultation with a chemist is needed to ensure compatibility of data sets.
Representativeness	Sample data must accurately reflect the site characteristics to effectively represent the site's risk to human health and the environment. Hot spots and exposure pathway media must have representative data.	Plans for collection of sufficient number of samples, a sample design that accounts for exposure pathway media, and an adequate number of samples for risk assessment should be discussed during scoping and documented in the SAP.

plan data collection efforts that maximize the useability of the data in baseline risk assessments:

- Section 3.1-Data Useability Criteria
- Section 3.2-Preliminary Sampling Issues
- Section 3.3-Preliminary Analytical Issues

Appendices contain additional tables and reference materials for use in the planning process.

3.1 Data Useability Criteria

Exhibit 3-2 lists the six Data Useability Criteria involved in planning for the risk assessment, summarizes the importance of each criterion to risk assessment, and lists suggested actions that can be taken during the planning process to improve the useability of the analytical data. The following sections define each criterion and describe its effect on risk assessment.

3.1.1 DATA SOURCES

The data sources selected during the RI planning process are dependent upon the type of data required and their intended use. Data collected prior to the RI are considered historical; data collected during the RI are considered current and are usually specified in the RI planning process. Data may be analytical or non-analytical. Examples of historical non-analytical data are site records, manifests, and disposal records. Historical analytical data that are often available from the Preliminary Assessment/Site Investigation (PA/SI) include reports on the physical testing, screening, and analysis of samples. The same analytical data requirements apply, whether the data are current or historical. The minimum criteria for analytical data are discussed in Chapter 5.

Exhibit 3-3 identifies available data sources and their primary use(s) in the risk assessment process. Historical (pre-RI) and RI (current) analytical data sources are briefly discussed.

EXHIBIT 3-2

IMPACT OF DATA USEABILITY CRITERIA IN PLANNING FOR THE BASELINE RISK ASSESSMENT (continued)

DATA USEABILITY CRITERION	IMPORTANCE	SUGGESTED ACTION
Precision	If the reported result is near the concentration of concern, it is necessary to be as precise as possible in order to minimize false negatives.	Plan for the use of quality control samples (duplicates, replicates and/or collocated samples). Assess confidence limits from the quality control sample data.
Accuracy	Quantitative accuracy information is critical when results are reported near the level of concern. Contamination in the field, shipping or laboratory may skew the analytical results. Instruments that are not calibrated or tuned properly may also bias results. The use of data that is biased affects the interpretation of risk levels.	Plan and assess quality control data (blanks, spikes, performance evaluation samples) to measure bias in sampling and analysis. A chemist should be consulted to interpret qualified data reported near a concentration of concern.
Data Review (3.1.5)	Use of preliminary data or partially reviewed data can conserve time and resources by allowing modification of the sampling plan while the RI is in process. Critical analytes and samples used for quantitative risk assessment require a full data review. Other analytes and samples may be of less concern.	Decisions regarding level and depth of review will conserve time and project resources and should be made in conjunction with the RPM and analytical chemist.
Reports to the Risk Assessor (3.1.6)	Data are more useful if reported in a format that provides readability as well as additional clarifying information. Sample quantitation limits, narrative, and qualifiers that are fully explained reduce the time and effort required in interpreting and using the analytical results. Limitations can be readily identified and documented in the risk assessment report.	During scoping, plan for a report format and include it in the SAP. Communication with the data reviewer will aid the generation of a specific report format.

EXHIBIT 3-3

DATA SOURCES AND THEIR USE IN RISK ASSESSMENT

Available Data Sources	Data Type	Primary Use(s)
PA/SI Data	Analytical	- Quantitative Risk Assessment - Trends
Hazard Ranking System (HRS) Documentation	Site records, Manifests, PA/SI, Analytical	- Quantitative Risk Assessment - Trends - Planning (chemicals present)
Listing Site Inspection (LSI)	Site records, PA/SI, Analytical	- Quantitative Risk Assessment - Trends - Planning (chemicals present)
Site Records on Removal and Disposal	Administrative	- Planning (chemicals present)
Toxic Release Inventory System (TRIS): Industry-Specific	Chemical discharge	- Planning (chemicals present)
Site, Source and Media Characteristics	Physical parameters (e.g., meteorological, geological)	- Fate and Transport - Define Exposure Pathways
Field Screening	Analytical	- Preliminary Assessment - Site Characterization
Field Analytical	Analytical	- Quantitative Risk Assessment - Site Characterization
Fixed Laboratory[1]-CLP, Non-CLP (EPA, State, PRP, Private)	Analytical	- Quantitative Risk Assessment - Reference - Broad Screen - Confirmatory - Site Characterization

[1] Mobile laboratories often have available the same instrumentation as fixed laboratories with the exception of ICP or MS.

Data sources prior to remedial investigation

Historical analytical data or a broad spectrum analysis should be used to initially identify the chemicals of potential concern or exposure areas.

Historical data sources may be used to determine sampling location and analytical approaches in the RI. Access to historical site data is critical to the identification of exposure pathways prior to determining the sample design. Historical analytical data are often available from the PA/SI. Early site inspections may locate industrial process information that suggests chemicals of potential concern. These background data indicate industry-specific analytes and general levels of contamination that are useful in the development of the sample design and the selection of analytical methods. Sources of historical analytical data for baseline risk assessment include: the PA/SI, Hazard Ranking System (HRS) documentation, the listing site inspection (LSI), site records on removal and disposal, and industry-specific systems for chemical discharge permits. Results from analyses by State or local governments may also indicate chemicals of potential concern.

The quality of historical data must be determined prior to its use in the RI. The difficulty in using historical analytical data in the RI is that methods and detection limits may not be documented. Also, whether data review was performed may not be known. This information is required if analytical data are to be used in the quantitative components of the risk assessment.

Historical analytical data of unknown quality may be used in developing the conceptual model or as a basis for scoping, but not in the determination of exposure concentrations. Analytical data from the PA/SI that meet minimum data useability requirements can be combined with data from the RI to estimate exposure concentrations. Similarly, historical data of lower quality may be used if the concentrations are confirmed by subsequent RI analyses.

Data sources for the remedial investigation

The planning process for the RI identifies gaps in the analytical data and determines additional data collection requirements. Three types of analytical data sources can be used during the RI to acquire analytical data for a risk assessment. These include field screening, field analyses, and fixed laboratory analyses.

- Field screening can be performed using chemical field test kits, ion-specific probes, and other monitoring equipment but should be confirmed by other techniques.
- Field analyses can be performed using instruments and procedures equivalent to fixed laboratory analyses and produce legally defensible data if quality control procedures are implemented.
- Fixed laboratory analyses are particularly useful for broad spectrum and confirmation analyses and generally provide more information over a wider range of analytes than field analyses.

A discussion of issues related to field and fixed laboratory analyses is presented in Section 3.3.7.

Analytical services are expensive and are a significant budget item within Superfund. Although, as a service, CLP costs do not appear on the RI/FS project budget, CLP resources should be conserved when possible. Excessive CLP tests for one site may preclude analysis needed at another. Analyte-specific methods may be used for previously identified chemicals and may provide more accurate results but should follow a broad spectrum analysis. Site samples analyzed by CLP services take an average of 35 days to produce results and data review may add significantly to this. A well-run mobile laboratory can quickly produce good "first look" results, and useful results can be followed up immediately while on site. Mobile laboratory services could replace some CLP services if analytical capabilities are determined to be adequate and minimum quality control requirements are met.

3.1.2 DOCUMENTATION

In order to provide a basis for assessing a data collection activity and sample analysis, it is essential to document certain information. During the scoping of the RI, plans should be made for documenting the data collection activities. This RI documentation can be used later to evaluate completeness, comparability, representativeness, accuracy, and precision of the analytical data sets. Four major types of documentation are produced during an RI:

- Sampling and Analysis Plan (SAP), including a Quality Assurance Project Plan (QAPjP).
- Standard operating procedures (SOPs).
- Field and analytical records.
- Chain-of-custody records.

A list of all the specific information required in these documents is normally contained in the SAP (EPA 1989a).

The end use requirements for the data must be clearly established as part of the planning objectives of the scoping meeting and documented in the SAP. The quality objectives for assessing data against the stated performance objectives should also be determined during the planning process and documented in the SAP.

Standard operating procedures (SOPs) and field/analytical records

Data collection and analysis procedures must be accurately documented in order to substantiate the analysis of the sample, conclusions derived from the data, and the reliability of the reported analytical data. Therefore, SOPs for field or analytical methods must be written for all field and laboratory processes. SOPs provide consistency in how samples are collected and analyzed, and determine the level of systematic error associated with data collection and analysis. Exhibit 3-4 lists the types of SOPs, field records, and analytical records that are usually associated with RI data collection and analyses, and relates the importance of each to the risk assessment.

EXHIBIT 3-4

RELATIVE IMPORTANCE OF SAMPLING AND ANALYSIS PLAN AND RECORDS IN PLANNING FOR RISK ASSESSMENT

DOCUMENTATION	IMPORTANCE
Sampling and Analysis Plan	
• Selection and Identification of Sampling Points	Critical
• Sample Collection SOP	High
• Analytical Procedures or Protocols	High
• Data Reporting and Review SOP	High
• QA Project Plan	High
• Method-Specific QC Procedures	Medium
• QA/QC Procedures	Medium
• Documented Procedures for Corrective Action	Medium
• Instrument Monitoring SOP Including Corrective Action and Maintenance	Medium
• Sample Preservation and Shipping SOP	Medium
• Sample Receipt, Custody, Tracking and Storage SOP	Low
• Installation and Monitoring of Equipment SOP	Low
Field and Analytical Records	
• Field Log Records	High
• Field Information Describing Weather Conditions, Physical Parameters or Site-Specific Geology	High
• Documentation for Deviations from SAP and SOPs	High
• Field Decisions/Documentation	High
• Data from Analysis - raw data such as instrument output, spectra, chromotograms and laboratory narrative	Medium
• Internal Laboratory Records	Low

KEY
Critical - Essential to the useability of data for risk assessment.
High - Should be addressed in planning for risk assessment.
Medium - Primarily impacts how data are qualified in risk assessment.
Low - Has little effect on useability of data for risk assessment.

All deviations from the referenced SOPs should be pre-approved by the RPM and documented. Samples that are not collected or analyzed in accordance with established SOPs may be of limited use because their quality cannot be determined.

Chain-of-custody

The technical team must decide during scoping what data may be used for cost recovery actions, and plan accordingly for the use of full scale chain-of-custody or less formal chain-of-custody procedures. Full scale chain-of-custody is required for cost recovery and enforcement actions, but is not a minimum requirement for risk assessment. Full scale chain-of-custody includes sample labels and formal documentation that prove the sample was not tampered with or lost in the data collection and analysis process. For risk assessment, limited chain-of-custody can be applied, as long as all data can be clearly identified with dates and sampling points. Sample identity is verifiable from the collector's notebook and laboratory data sheets, as well as from a formal chain-of-custody.

Exhibit 3-5 lists the procedures associated with chain-of-custody documentation, including the mechanism to prove chain-of-custody and the data collection processes involved, and relates the importance of each item to the risk assessment.

EXHIBIT 3-5

RELATIVE IMPORTANCE OF CHAIN-OF-CUSTODY DOCUMENTATION AND ACTIVITIES IN PLANNING FOR RISK ASSESSMENT

CHAIN-OF-CUSTODY DOCUMENTATION	IMPORTANCE
Mechanism to Prove Chain-of-Custody	
• Documentation Linking Data to Sample Point	Critical
• Sampling Date	Critical
• Sample Tags	Medium
• Custody Seals	Low
• Laboratory Receipt and Tracking	Low
Activity	
• Sampling	Medium
• Field Analysis	Medium
• Shipping	Medium
• Internal Laboratory	Low

KEY

Critical - Essential to the useability of data for risk assessment.
High - Should be addressed in planning for risk assessment.
Medium - Primarily impacts how data are qualified in risk assessment.
Low - Has little effect on useability of data for risk assessment.

3.1.3 ANALYTICAL METHODS AND DETECTION LIMITS

The choice of analytical methods is a crucial step in RI planning. Appropriate analytical methods have detection limits that meet risk assessment requirements for chemicals of potential concern and have sufficient quality control measures to ensure confident target compound identification and quantitation. The detection limit of the method directly affects the useability of data because chemicals reported near the detection limit have a greater possibility of false negatives and positives. The risk assessor or RPM must consult a chemist for assistance when using methods that have detection limits near or above the required action level.

3.1.4 DATA QUALITY INDICATORS

This section discusses each of five data quality indicators as they relate to the assessment of sampling and analysis.

- Completeness
- Comparability
- Representativeness
- Precision
- Accuracy

The data and accompanying documentation are used to evaluate these indicators. The risk assessor may need to communicate with a chemist or statistician after the data collection process has been completed to evaluate data quality indicators. Therefore, the SAP, field and analytical records, and SOPs should be accessible. Exhibits 3-6 and 3-7 summarize the importance of data quality indicators for sampling and analysis (respectively) to risk assessment and list suggested planning actions.

The definition of each of the data quality indicators is presented in the following paragraphs. Note that the specific use of the indicators to measure data useability is different for sampling and analysis. For example, completeness as applied to sampling refers to the number of samples to be collected. Completeness as applied to analytical performance primarily applies to the number of data points that indicate an analytical result for each chemical of interest (e.g., 10 samples analyzed for 25 chemicals will produce 250 data points total, (10 data points for each chemical).

EXHIBIT 3-6

IMPACT OF DATA QUALITY INDICATORS ON SAMPLING CONSIDERATIONS

DATA QUALITY INDICATOR	IMPORTANCE	SUGGESTED ACTION
Completeness	May decrease sample representativeness for identification of false negatives and estimate of average concentration.	Stipulate SOPs for sample collection and handling in SAP to ensure complete and valid sampling.
Comparability	Ability to combine analytical results across sampling episodes and time periods.	Use the same unbiased sample design across episodes and time periods.
Representativeness	Avoidance of false negatives and false positives (field sampling contamination). Potential bias of concentration estimates.	Use an unbiased sample design. Collect additional samples as required.
Precision	Increased uncertainty of risk assessment because of increasing variability in concentration estimates.	Increase number of samples. Use appropriate sample designs.
Accuracy	May result in bias due to contamination during sampling process. May result in bias due to loss of sample from improper collection or handling (loss of volatiles). May result in false positives and inaccurate estimates of concentration.	Use SOPs for sample collection and handling. Use quality control results for monitoring.

Completeness

Completeness is a measure of the amount of useable data resulting from a data collection activity. The required level of completeness should be defined for the number of samples required in the sample design and for the quantity of useable data for chemical-specific data points needed to meet performance objectives. All defined data items must be obtained for critical samples and chemicals.

Problems that occur during data collection and analysis affect the completeness of a data set. Fewer samples may be collected and analyzed than originally planned because of site access problems. Laboratory performance may be affected if capacity is exceeded, causing data to be rejected. Some samples may not be analyzed due to matrix problems. Samples that are invalid due to holding time violations may have to be re-collected or the data set may be determined as useable only to a limited extent. Therefore, advance planning in identifying critical samples and the use of alternative sampling procedures are both necessary to ensure completeness of a data set for the baseline risk assessment.

EXHIBIT 3-7

IMPACT OF DATA QUALITY ON ANALYTICAL CONSIDERATIONS

DATA QUALITY INDICATOR	ASSOCIATED ISSUES	SUGGESTED ACTION
Completeness	Poor data quality or lost samples reduce data set and decrease confidence in supporting information.	Prepare SOPs to support sample tracking and analytical procedures, review, and reporting aspects of laboratory operations.
Comparability	Ability to combine analytical results acquired from various sources using different methods for samples taken over the period of investigation.	Reference analyte-specific method performance characteristics. Reference applicable fate and transport documentation. Anticipate field and laboratory variability.
Representativeness	Potential for false negatives.	Include requirement for broad spectrum analyses across site area. Analyses should include samples considered positive and negative for anticipated chemicals of potential concern.
	Nonhomogeneity of sample.	Assure sample is mixed and adequately represents the environment.
	Potential for false positives.	Include provision for blank (transport, storage and analytical) QC monitoring.
	Potential for change in sample before analysis.	Field methods have an advantage in direct site contact that minimizes transport and storage variability.
Precision	Monitoring.	Method QC component and site-specific QC samples from external reference are best monitoring techniques.
	Confidence in distinction between site and background levels of contamination. Primary importance when action limit approaches detection limit.	Method QC component can utilize site-specific QC samples taken over time and should be considered in method selection if anticipated site levels are near the method detection limit and above action limits.
Accuracy	Confidence in distinction between site and background levels of contamination. As concentration of concern approaches the detection limit, the differentiation includes confidence in the determination of presence or absence of chemical of potential concern.	Broad spectrum screening methods may have significant negative bias for chemicals of potential concern. If site levels approach concentrations of concern, method accuracy and detection limits should be considered in selection.

Comparability

Comparability expresses the confidence with which data are considered to be equivalent. Combined data sets are used regularly to develop quantitative estimates of risk. The ability to compare data sets is particularly critical when a set of data for a specific parameter is applied to a particular concentration level of concern.

Comparability for sampling primarily involves sample designs and time periods. Comparability for analyses encompasses issues of different analytical methodologies, detection limits, laboratories, units of measure, and sample preparation procedures. Using routine available methods and consistent units of measure, when planning for data collection that will span several different sampling events and laboratories, will increase the likelihood that analytical results will be comparable. If field analyses are used in a quantitative risk assessment with confirmation samples, careful attention must be taken to assure that the data from field and fixed laboratories are comparable or equivalent. When precision and accuracy are known, the data sets can be compared with confidence. Planning ahead for comparable sample designs, methods, quality control, and documentation will aid the risk assessor in combining data sets for the exposure pathway.

Representativeness

For risk assessment, representativeness expresses the extent to which data define the risk to human health and the environment. Samples must be collected in a way that generates data which reflect the site's characteristics, and must be analyzed in a way which represents the properties of the field sample. The homogeneity of the sample, use of appropriate handling, storage, and preservation procedures, and the detection of any artifacts of laboratory analyses such as blank contamination are particularly important. Representativeness for risk assessment primarily relates to the exposure pathways because sampling and analyses must adequately represent each exposure pathway.

Representativeness can be maximized by ensuring that sampling locations are selected properly, potential hot spots are addressed, and a sufficient number of samples are collected over a specified time span. The SAP should describe sampling techniques and the rationale used to select sampling locations.

Precision

Precision is a quantitative measure of the variability of a set of measurements compared to the mean and is usually reported as a coefficient of variation or a standard deviation of the arithmetic mean. Results of quality control samples are used to calculate the precision of the measurement process. Measurement error is a mixture of sample collection and analytical factors. Collection of field duplicate samples will optimize the ability of sample results to distinguish sampling from analytical variability. Analytical variability can be measured through the analysis of laboratory duplicates or through multiple analyses of performance evaluation samples. If analytical results are reported near a concentration of concern, the standard deviation or coefficient of variation can be used to determine the confidence level of the reported data. A statistician or a chemist should be consulted if this determination is difficult.

Accuracy

Accuracy is a measure of the closeness of a reported concentration to the true value. This measure is usually expressed as bias (high or low) and determined by calculating percent recovery from spiked samples. The risk assessor should know the required level of certainty for the end use of the data when reviewing accuracy information. When results are reported at or near a concentration of concern, accuracy information is critical.

Contamination in the field, during shipping, or at the laboratory that may skew the analytical results is determined by the results of blank analyses. Field and trip blanks should be used during the RI to identify contamination and the associated bias related to sample collection or shipment. Method blanks should be used to monitor laboratory contamination.

3.1.5 DATA REVIEW

This section discusses the importance of alternative levels of data review to the risk assessment. The two major effects on data useability from the data review are:

- The timeliness of the data review.
- The level and depth of review (e.g., entire site, specific sample focus, specific analyte focus, amount of quality control data assessed).

A tiered approach using combinations of data review alternatives is recommended so that the risk assessor can use preliminary data before extensive review. It is essential for the RPM, risk assessor, and the project chemist to reach a concensus on the level and depth of data review to be performed. Exhibit 3-8 provides a summary of the characteristics and uses of different levels of data review.

EXHIBIT 3-8

STAGES OF REVIEW OF ANALYTICAL DATA

Level of Review	Samples	Analytes	Parameters	Potential Uses
None	Initial	All	Analytical results	Qualitatively identify risk assessment analytes. Modify SAP.
Full	Initial samples analyzed for broad spectrum components	All	All analytical results, QC, and raw data	Quantitatively confirm risk assessment. Modify SAP. Modify review process.
Partial	Critical samples for all analytes or all samples for critical analytes		Selected analytical results, QC, or raw data	Improve timeliness, overall efficiency, save resourses.
Automated	All	All	Parameters available to the automated system. No raw data are evaluated.	Improve timeliness, consistency, cost effectiveness. May electronically transfer to a database. Eliminate transcription errors.

Timing of review

Preliminary data should be provided to the risk assessor as soon as they are available to expedite the risk assessment.

Plans for the timing of the data review should be made prior to data collection and analysis. The risk assessor uses preliminary data in a qualitative manner to identify compounds for toxicity studies and, initially, to ascertain trends in concentrations and distributions of the analytes of concern, plan for additional sampling, and request additional analyses. Using data as they become available will usually reduce the time needed to complete the risk assessment. However, all data must receive a minimum level of review before use in the quantitative aspects of risk assessment.

Level and depth of review

The RPM may select different levels of data review, in consultation with the risk assessor or other data users and the project chemist. All data must have a minimum level of review. Data review levels can range from all site samples with all reported data, to specific key analytes and samples and may be specified in EPA regional policies. Careful consideration is required in selecting a level of review that is consistent with data quality requirements. A full data review will minimize false positives, false negatives, calculation errors, and transcription errors. Partial review should be utilized only after broad spectrum analysis results have undergone full review. Time and resource constraints can be balanced with flexible use of data review alternatives.

Depth of data review refers to the selection of evaluation criteria, ranging from generalized criteria that may affect an entire data set (e.g., holding time) to analyte specific criteria that may affect only a portion of results from one sample (e.g., recovery of a surrogate spike for organics or analyte spike recovery for inorganics). The RPM must decide the depth of review for each data source to provide a balance between useability of data and resource constraints. Data used quantitatively must be reviewed on an analyte-specific basis.

Automated data review systems

Automated data review systems can be used to assess all samples and analytes for which there are computer-readable data in the format required by the automated system. The depth of review will depend on both the data and the assessment system. The primary advantages of automated data review systems for the risk assessor are timeliness, the elimination of transcription errors that can be introduced during manual review processes, and computer-readable output, which usually includes results and qualifiers. This information can be transferred to computer-assisted risk assessment and exposure modeling systems. Exhibit 3-9 provides a list of software that aid data review and evaluation.

EXHIBIT 3-9

AUTOMATED SYSTEMS[1] TO SUPPORT DATA REVIEW

SYSTEM	EPA CONTACT	DESCRIPTION
CADRE Computer Assisted Data Review and Evaluation	John Nocerino Quality Assurance Div. USEPA, EMSL-LV (702) 798-2110	An automated evaluation system that accepts files from CLP format disk delivery or mainframe transfer and assesses data based on USEPA Functional Guidelines for Data Validation (default criteria). System accepts manual entry of other data sets, and rules for evaluation can be user-defined to reflect specific information needs. (Inorganic system is in development.)
eDATA Electronic Data Transfer and Validation System	William Coakley USEPA Emergency Response Team (201) 906-6921	An automated review system developed to assist in rapid evaluation of data in emergency response. May be applicable for both CLP and non-CLP data. System combines DQOs, pre-established site specifications, QC criteria, and sample collection data with laboratory results to determine useability.

[1] All systems will run on any IBM compatible PC AT with 640K RAM (minimum). A fixed disk is recommended.

3.1.6 REPORTS FROM SAMPLING AND ANALYSIS TO RISK ASSESSOR

Preliminary data reports assist the risk assessor in identifying sampling or analytical problems early enough so that corrective actions can be taken during data collection to increase the quality of a quantitative risk assessment. The request for preliminary data should be made during RI planning and formalized in the SAP. The use of such information may reduce the overall time required for the risk assessment.

Exhibit 3-10 lists the final data and documentation needed to support risk assessment, and rates the importance of each item. Data are most useable when reported in a readable format and accompanied by additional, clarifying information. Report structures are usually defined by Regional policy and include specification of the format for manual summaries and machine-readable data (where required) and for summary tables from data review. The RPM can ask the data reviewers to provide a data summary table listing sample results, sample quantitation limits, and qualifiers on diskette for downloading into Risk*Assistant, spreadsheets, or other software programs that the risk assessor may use. An example of a recommended tabular results report format appears in Appendix I.

The data reviewer should provide a narrative summary, that is comprehensible to a nonchemist, describing specific sampling or analytical problems, data qualification flags, detection limit definitions, and interpretation of quality control data. This summary must always be followed and supported by a detailed commentary that explicitly addresses each item from the narrative on a technical basis. The commentary facilitates data use by providing a technical justification for data qualification. If a nontechnical narrative is unavailable, the risk assessor must (at a minimum) be provided with explanations of qualification flags, detection limits, and interpretation of quality control data (see Appendices I, V, VI and VII for examples). A chemist familiar with the site can be requested to interpret the analytical review with site-specific information, such as physical site conditions that affect sample results.

3.2 Preliminary sampling issues

The design and assessment of environmental sampling procedures is a complex subject and well beyond the scope of this guidance manual, but involves criteria which need to be addressed. Statistical and non-statistical sampling considerations provide the risk assessor with a basis for identifying sample design and data collection problems, interpreting the significance of analytical error, and selecting methods based on the expected contribution of sampling and analytical components to total measurement error. A comprehensive discussion of environmental sampling procedures is given in Principles of Environmental Sampling (Keith 1987, 1990a) and Methods for

Evaluating the Attainment of Cleanup Standards (EPA 1989i).

This section provides a framework, key issues, and tools and guidance for use by non-statisticians to determine the potential impact of sampling procedures on data useability for risk assessment and to identify situations that require statistical support. The primary purpose of this guidance is to increase the statistical sophistication and understanding of RPMs and risk assessors. Major sampling concerns are discussed as issues and reminders or identified as questions to be resolved. Sampling design and assessment tools used in this section include reference tables, statistical formulas and checklists. Guidelines are presented in the form of rules of thumb. A Sample Design Selection Worksheet with step-by-step instructions is presented in Chapter 4.

Several assumptions concerning sampling and associated statistical procedures have been made to simplify the discussion in this section. They are:

- The RPM and risk assessor are familiar with basic environmental sampling and statistical terms and logic.
- Statisticians will be consulted for any significant problems or situations violating these assumptions or not covered in the guidance.
- Detailed discussions of statistical sampling issues by medium and sample design are currently available (Keith 1987 and 1990a, EPA 1989i).
- Variations of stratified random or systematic random sampling (grid) have been used. Systematic sampling requires special variance calculations in order to estimate statistical performance parameters such as power and confidence level; these are not addressed in this manual.
- Chemical distributions are log normal in form or exist in some form which approximates normal when transformed (e.g., logarithmic). Measures of variability are given in transformed units. Parametric statistical tests are utilized in the examples. Such tests involve distributional assumptions but have high power with few samples.
- Sampling quality assurance procedures are not separate from analytical quality assurance procedures, especially in the area of sample collection and handling, even though the discussion will treat them separately.

This section also discusses sampling concepts and information on issues known to significantly affect sample design and assessment. Exhibit 3-11 summarizes the importance of each of the preliminary planning issues to the risk assessment and lists actions to be considered during the planning process to reduce or eliminate their effect on data useability.

EXHIBIT 3-10

DATA AND DOCUMENTATION NEEDED FOR RISK ASSESSMENT

DATA AND DOCUMENTATION	IMPORTANCE
• Site description with a detailed map indicating site location, showing the site relative to surrounding structures, terrain features, population or receptors, indicating air and water flow, and describing the operative industrial process if appropriate.	Critical
• Site map with sample locations identified.	Critical
• Description of sampling design and procedures including rationale.	Critical
• Description of analytical method used and detection limits including sample-specific quantitation limits (SQLs) and detection limits for non-detect data.	Critical
• Results given on a per-sample basis, qualified for analytical limitations and error, and accompanied by SQLs.	Critical
• Field conditions and physical parameter data as appropriate for the media involved in the exposure assessment.	Critical
• Narrative explanation of qualified data on an analyte and sample basis, indicating direction of bias.	High
• QC data results such as blanks, replicates and spikes for field and laboratory.	High
• Estimated quantities of compounds/tentatively identified compounds.	High
• Definitions and descriptions of flagged data.	High
• Results given in summary tables in alphabetical order.	Medium
• Raw data (instrument output, chromatograms, spectra).	Medium
• Definitions of technical jargon used in narratives.	Low

KEY
Critical - Essential to the useability of data for risk assessment.
High - Should be addressed in planning for risk assessment.
Medium - Primarily impacts how data are qualified in risk assessment.
Low - Has little effect on useability of data for risk assessment.

3.2.1 CHEMICALS OF POTENTIAL CONCERN

Chemicals of potential concern are chemicals that may be hazardous to human health and are identified at the site, initially from historical sources. Chemicals previously identified at Superfund sites have varying rates of occurrence, average concentrations, and coefficients of variation. These differences are a function of fate and transport properties, occurrence in different media, and interactions with other chemicals, in addition to use and disposal practices. Information on frequency and coefficient of variation determines the number of samples required to adequately characterize exposure pathways and is essential in designing sampling plans. Low frequencies of occurrence and high coefficients of variation mean that more samples will be required to characterize the exposure

EXHIBIT 3-11

IMPACT OF SAMPLING ISSUES ON RISK ASSESSMENT

ISSUE	IMPORTANCE	SUGGESTED ACTION
Chemicals of Potential Concern (3.2.1)	Chemicals have different rates of occurrence and coefficients of variation. This impacts the probability of false negatives and reduces confidence limits for estimates of concentration.	Increase the number of samples for chemicals with low occurrence and/or high coefficients of variability.
Sampling Variability vs. Measurement Error (3.2.2)	Sampling variability can exceed measurement error by a factor of three to four (EPA 1989c). Sampling variability increases uncertainty or variability; measurement error increases bias.	Reduce sampling variability by taking more samples (using less expensive methods). This allows more samples to be analyzed. Use QC samples to estimate and control bias.
Media Variability (3.2.3)	Sampling problems vary widely by media as do variability and bias.	Design media-specific sampling approaches.
Sample Preparation and Sample Preservation (3.2.4)	Contamination can be introduced during sample preparation, producing false positives. Filtering may remove contaminants sorbed on particles.	Use blanks at sources of potential contamination. Collect filtered and unfiltered samples.
Identification of Exposure Pathways (3.2.5)	Not all samples taken in a site characterization are useful for risk assessment. Often only a few samples have been taken in the area of interest.	Sample designs should specifically address exposure pathways. Risk assessors should participate in scoping meeting.
Use of Judgmental or Purposive Sample Design (3.2.6)	Statistical sample designs may be costly and do not take advantage of known areas of contamination.	Use judgmental sampling to identify contaminated areas, then use an unbiased method to characterize exposure.

EXHIBIT 3-12

MEDIAN COEFFICIENT OF VARIATION FOR CHEMICALS OF POTENTIAL CONCERN

Chemical of Potential Concern	Soil/Sediment Median%CV [2]	Number of sites at which chemical was detected	Water Median%CV [2]	Number of sites at which chemical was detected [3]
Chloromethane	16.7	61	50.0	134
Trichloromethane/Chloroform	53.9	392	45.2	519
Tetrachloromethane/Carbon tetrachloride	15.4	38	9.3	90
1,2-dichloroethane	17.8	64	24.7	158
Tetrachloroethane	17.0	56	17.4	101
Vinyl chloride	11.0	55	15.7	197
Tetrachloroethene	24.5	392	33.3	367
Dichloropropane	19.0	29	13.3	79
Isophorone	0.7	74	18.4	72
Bis (2-chloroethyl) ether	0.5	10	20.1	34
1,4-dichlorobenzene	0.9	120	17.3	119
Bis (2-ethylhexyl) phthalate	0.7	1197	29.5	782
Benzo(a) pyrene	0.5	1058	10.8	76
Styrene	16.9	117	33.3	69
N-nitrosodiphenylamine	0.5	142	30.5	96
DDE	4.5	329	813.0	40
DDT	2.9	521	588.2	125
Dieldrin	4.4	274	3.3	101
Heptachlor	4.8	249	351.9	151
Gamma-BHC (lindane)	6.3	142	454.1	134
PCB1260	0.21	251	41.7	23
Arsenic	40.3	1098	58.0	940
Beryllium	271.3	1091	100.0	931
Cadmium	134.6	1096	33.7	945
Chromium	11.9	1098	23.0	948
Mercury	1032.3	1098	500.0	948
Lead (Pb)	10.9	1098	97.3	939

[1] List of chemicals of potential concern is derived from health-based levels and frequency of occurance at Superfund sites listed in the CLP Statistical Database. (Number of sites for which data exist totals 8,900.)

[2] Median percent coefficient of variation of analyte concentrations.

[3] November 1988 to present.

pathways of interest. Situations potentially involving false negatives occur as variability increases and occurrence rates decrease.

The prevention of false negatives in sampling and analysis is of more concern to risk assessment than the prevention of false positives in order to be protective of human health.

Data for aqueous and soil/sediment matrices on frequently occurring chemicals of potential concern, and releases from industries known to produce waste commonly found at Superfund sites are available for volatiles, extractable organics, pesticides/PCBs, tentatively identified organic compounds, and metals (See Appendix II). Data are also available for the calculation of site-specific coefficients of variation. Exhibit 3-12 indicates the occurrence rates and coefficients of variation for selected chemicals of potential concern to risk assessors.

3.2.2 SAMPLING VARIABILITY VERSUS MEASUREMENT ERROR

Sampling variability and measurement error are two key concepts involved in planning and assessing sample collection efforts. Each is discussed in the context of evaluating strategies for the collection of both site and background samples. Exhibit 3-13 defines and illustrates sources of sampling variability and measurement error.

EXHIBIT 3-13

SAMPLING VARIABILITY AND MEASUREMENT ERROR

Sampling variability: the variation between true sample values that is a function of the spatial variation in the pollutant concentrations.

Measurement-error variation: the variation induced by differences between true sample values and reported values. Error is a function of the following:

- Sample collection variation
- Samplepreparation/handling/preservation/storage variation
- Analytical variation
- Data processing variation

Most sampling plans are a necessary compromise between cost and confidence level. Basically, two types of decisions must be made:

- Determine the statistical performance necessary to produce the quality of data appropriate to meet the risk assessor's sampling variability performance objectives.
- Determine the types and numbers of quality control samples required to detect and estimate measurement error.

Large variation of a contaminant in a medium indicates that the number of samples should be increased or that the medium should be stratified to reduce variability.

Sampling plans attempt to minimize and estimate both sampling variability and measurement error. Sampling variability affects the degree of confidence and power the risk assessor can expect. Confidence is the ability to detect a false positive hypothesis, and power is the ability to detect a false negative. Power is more important for risk assessment. An estimate of the sampling variability that is a function of the spatial variation in the concentrations of chemicals of potential concern is obtained by calculating the coefficient of variation for each chemical. When the coefficient of variation is less than 20% and a substantial quantity of data are available, the effect of spatial and temporal variation on concentrations of chemicals of potential concern is minimal, and the power and certainty of statistical tests is high (EPA 1989c).

Measurement error is estimated using the results of the quality control samples and represents the difference between the true sample value and the reported value. This difference has five basic sources: the contaminant being measured, sample collection procedures, sample handling procedures, analytical proce-

EXHIBIT 3-14

MEASUREMENT OF VARIATION AND BIAS USING FIELD QUALITY CONTROL SAMPLES

Quality Control Sample Types	Variation or Bias Measured
Field duplicate	Provides data required to estimate the sum of subsampling and analytical variances.
Field evaluation sample (in pairs)	Provides data obtained from field duplicate samples and their associated routine samples, allowing calculation of unbiased estimates of the total measurement error variance, the between batch error variance, and the sample collection error variance.
Field blank	Provides data required to estimate the bias due to contamination introduced during field sampling or cleaning procedures. Also measures contamination at laboratory. Compare with laboratory method blank to determine source of contamination.
Field rinsate	Provides data required to estimate the sum of the bias caused by contamination at the time of sampling from sampling equipment and by analysis and data handling. Indicates cross-contamination and potential contamination due to sampling devices.
Trip blank	Provides data required to estimate the bias due to contamination from migration of volatile organic chemicals into the sample during sample shipping from the field and sample storage at the laboratory.

Source: EPA 1990b.

dures, and data production procedures. Measurement error due to analytical procedures is discussed in Section 3.3 under analytical considerations. Measurement error due to sampling is estimated by examining the precision of results from field duplicates. The minimum recommended number of field duplicates is one for every 20 environmental samples (or a frequency of 5%). A minimum of one set of duplicates should be taken per medium sampled unless many strata are involved; five sets are recommended. Exhibit 3-14 summarizes the types and uses of quality control samples in defining variation and bias.

The contribution of sampling variability to total error is typically much greater than the analytical error.

In summarizing the discussion of sampling and measurement error, one finding puts the concepts in perspective: "An analysis of the components of total error from soils data from an NPL site sampled for PCBs indicated that 92% of the total variation came from the location of the sample and 8% from the measurement process" (EPA 1989c). Of the 8%, less than 1% could be attributed to the analytical process. The rest is attributable to sample collection, sample handling, data processing and pollutant characteristics. Sampling variability is often three to four times that introduced by measurement error. Exceptions to this observation on the components of variation or sources of error occur in instances of poor method performance for specific analytes.

3.2.3 MEDIA VARIABILITY

Appropriate samples must be collected from each medium of concern and, for heterogeneous media, from designated strata. Media to be sampled should include those currently uncontaminated but of concern, as well as those currently contaminated. For media of a heterogeneous nature (e.g., soil, surface water, and hazardous waste), strata should be established and samples specified by stratum to reduce variability, the coefficient of variation and the required number of samples.

Sampling considerations vary according to media. The sampling concern may involve contaminant occurrence, temporal variation, spatial variation, sample collection, or sample preservation. Exhibit 3-15 indicates potential sampling problem areas for each medium. Problem areas are classified relative to other media. RPMs can use this exhibit to identify possible sampling problems in each medium and plan for them in the data collection design. Sample designs must be structured to identify and address hot spots. Exhibit 3-16 shows the sources of uncertainty across media. Note: Information needed for fate and transport modeling should be obtained during a site sampling investigation. This information also differs by the medium of concern (EPA 1989a).

EXHIBIT 3-15

IMPORTANCE OF MAJOR SAMPLING ISSUES IN EACH MEDIUM

MAJOR SAMPLING ISSUES	PROBLEM LIKELIHOOD BY MEDIUM					
	SOIL	GROUND WATER	SURFACE WATER	AIR	BIOTA	HAZARDOUS WASTE
Contaminant Migration	++		+	+		++
Temporal Variation		++	++	+	+	
Spacial Variation	++		++	+		++
Topographic/ Geological Properties	++	++		+		
Hot Spots	++					++
Sample Collection	+	+	++	++	+	+
Sample Preparation/ Handling	++	++	++	++	++	+
Sample Storage		++	++	++	++	
Sample Preservation		++	++		++	

Key: ++ = Likely source of significant sampling problem.

+ = Potential source of sampling problem.

Source: Keith 1990b.

EXHIBIT 3-16

SOURCES OF UNCERTAINTY THAT FREQUENTLY AFFECT CONFIDENCE IN ANALYTICAL RESULTS

SOURCE OF UNCERTAINTY	DEGREE OF SIGNIFICANCE BY MEDIUM				
	SOIL	WATER	AIR	BIOTA	HAZARDOUS WASTE
SAMPLING					
Design	++	+	++		+
Contamination	++	+	+		
Collection	+	++	++		+
Preparation	++			++	
Storage		++	++		
Preservation		++		++	
LABORATORY					
Storage	++	++	++	++	
Preparation	++/+	++/+		+	++
Analysis	++		+	++	++
Reporting			+		++
ANALYTE-SPECIFIC					
Volatility	++	+	+		
Photodegradation		+	+		
Chemical Degradation	+	++			
Microbial Degradation	++	++			
Contamination	++		++		

KEY:

++ = Likely source of significant error or uncertainty.

+ = Potentially significant source of error or uncertainty.

++/+ = Magnitude of effect determined by examination of data.

3.2.4 SAMPLE PREPARATION AND SAMPLE PRESERVATION

Some samples require preparation in the field in order to ensure that the results of analyses reflect the true characteristics of the sample. The use of sample filtration and compositing procedures is discussed in this section.

If the risk assessor needs to discriminate between the amount of analyte present in true solution in a sample and that amount sorbed to solid particles, then the sample must be filtered. Some samples, such as tap water, are never filtered because there is no particulate content. This filtration should be performed in the field as soon as possible after the sample has been taken and before any preservative has been added to the sample. Filtration often does not proceed smoothly. It is common practice only to filter a small proportion of all samples taken, and to perform analyses for the total content of the analyte in the majority of samples. Exhibit 3-17 depicts the effects of filtered versus unfiltered samples and other sample preparation issues.

Reducing the number of samples by compositing is also a form of sample preparation. Compositing may be performed to reduce analytical costs, or in situations where the risk assessor has determined that an average value will best characterize an exposure pathway. Compositing cannot be used for the identification of hot spots, but can be effective when averaging across the exposure area for the RME trespasser scenario. Caution should be exercised when compositing since low level detects can be averaged out and become non-detects.

Sample characteristics can be disturbed by post-sampling biological activity or by irreversible sorption of analytes of concern onto the walls of the sample container. A variety of acids and biocides used for preservation are discussed in standard works such as "Standard Methods for the Examination of Water and Wastewater" (Clesceri et al. Eds. 1989).

EXHIBIT 3-17

SAMPLE PREPARATION ISSUES

Issue	Action
Sample Integrity	Preservation – Acids, Biocides
Source of Analyte Media	Unfiltered Samples - Measure total analytes Filtered Samples - Discriminate sorbed and unsorbed analytes
Analyte Speciation	Choice of sample preparation protocols affects analyte speciation
Number of Samples to be Analyzed	Composite Samples (However, this raises the effective detection limit in proportion to the number of samples composited.)

3.2.5 IDENTIFICATION OF EXPOSURE PATHWAYS

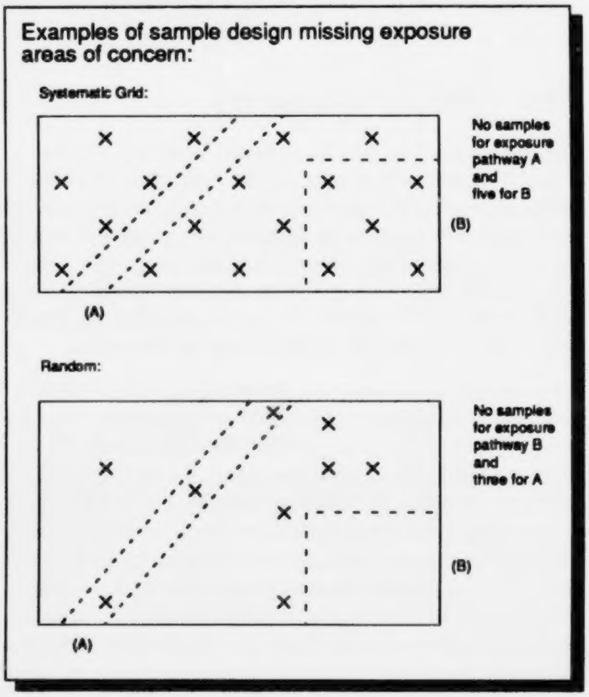
Current and future exposure pathways are often limited to particular areas of a site. If sampling activity can be concentrated in these areas, the precision and accuracy of the data supporting risk assessments can be improved.

Exposure pathways should be designated prior to the design of the sampling procedures. For the risk assessment, at least one broad spectrum analytical sample is required and two or three are recommended for each medium in an exposure pathway. If the site sample design fails to consider all exposure pathways and media, additional samples will be required.

The risk assessment requires the characterization of each exposure area for the site. Samples not falling within the areas of potential concern are not used in the identification of chemicals of potential concern nor in the calculation of reasonable maximum exposure concentration. Depending on exposure pathways, the risk assessor may utilize only a small number of samples that were collected at a site. Exhibit 3-18 shows why the identification of exposure pathways is critical to the sample design in order to maximize the number of samples that are useable in the risk assessment.

EXHIBIT 3-18

IDENTIFICATION OF EXPOSURE PATHWAYS PRIOR TO SAMPLE DESIGN IS CRITICAL TO RISK ASSESSMENT


Examples of sample design missing exposure areas of concern:
Systematic Grid:
No samples for exposure pathway A and five for B
(B)
(A)
Random:
No samples for exposure pathway B and three for A
(B)
(A)

3.2.6 USE OF JUDGMENTAL OR PURPOSIVE SAMPLE DESIGN

The use of judgmental or purposive designs that may specify sampling points based on existing site knowledge may be appropriate for the initial phase of site sampling or in situations where the risk assessment is performed using few samples. In such instances, non-statistical approaches may be more effective in accomplishing the purpose of the risk assessment for human health, than statistical designs with unacceptably large sampling variability.

Judgmental samples can be incorporated into a statistical design if the sampling procedures designate the area of suspected contamination as an exposure area or stratum. The judgmental samples are then selected randomly within the area of known contamination. This procedure allows the judgmental samples to be used later if a statistical design is developed as a result of the initial sampling. Under the procedures described, the initial judgmental samples are not considered biased for the exposure area. Exhibit 3-19 summarizes the strengths and weaknesses of biased and unbiased sample designs.

Resource constraints sometimes reduce the number of samples upon which the risk assessment will be conducted and therefore potentially increase the variability associated with the results. When the number of samples that can be taken is restricted, judgmental sampling may be able to identify the chemicals of potential concern even though the design will not enable an estimation of the uncertainty in quantitation of the amount of chemicals of potential concern present at the site. However, the RME or UCL cannot be calculated from results of a judgmental design. Bias can be avoided by using the procedures described in the previous paragraph.

EXHIBIT 3-19

STRENGTHS AND WEAKNESSES OF BIASED AND UNBIASED SAMPLE DESIGNS

Sample Design	Strengths	Weaknesses
Biased (judgmental, purposive)	• Uses knowledge of location • Limited resources • Timeliness	• Inability to calculate uncertainty • Inability to determine RME • Decreases representativeness • Increases probability of false negatives
Unbiased (random, systematic grid, geostatistical)	• Ability to calculate uncertainty • Ability to determine RME • Representativeness • Reduces probability of false negative	• Resource intensive • May require statistician • Timeliness

3.3 Preliminary analytical issues

This section describes technical issues that may affect the analytical procedures and therefore the data useability. A discussion of these issues will familiarize the reader with the terminology of analytical chemistry so that communication and problem resolution are more efficient. Analytical tools include reference tables, checklists, and comparisons of strengths and weaknesses of options available to the RI process. A Method Selection Worksheet is presented in Chapter 4 to assist in defining the issues for a specific RI.

Several assumptions concerning analytical procedures have been made in order to simplify the discussions in this section. It is assumed that:

EXHIBIT 3-20

IMPACT OF ANALYTICAL ISSUES ON RISK ASSESSMENT

ANALYTICAL ISSUE	IMPORTANCE	SUGGESTED ACTION
Chemicals of Potential Concern (3.3.1)	Chemicals of potential toxicological significance may be omitted.	Examine existing data and site history for industry-specific wastes to determine analytes for measurement. Perform broad spectrum analysis.
Library Search/ Tentatively Identified Compounds (3.3.2)	Identification and quantitation do not have high confidence.	Be prepared to request further analyses if potentially toxic compounds are discovered during screening. Compare results from multiple samplings or historical data.
Identification and Quantitation (3.3.3)	False negatives may occur when analytes are present near the method detection limit.	Use technique with definitive identification (e.g., GC-MS). Alternatively, use technique with definitive identification first, followed by another technique (e.g., GC) to achieve lower quantitation limits.
Detection Limits (3.3.4)	Risk levels may be at concentrations lower than measureable.	Review available methods for appropriate detection limit.
Media Variability (3.3.5)	Variability and bias may be introduced to analytical measurements.	Use environmental samples as QC samples to determine recovery and reproducibility in the sample media.
Sample Preparation (3.3.6)	Variability and bias may be introduced to analytical measurements.	Select analytical methods based on sample medium and strengths of the sample preparation technique.
Fixed Laboratory vs. Field Analyses (3.3.7)	Tradeoffs required with regard to speed, precision, accuracy, personnel, identification, quantitation and detection limits.	Consider options and set priorities.
Laboratory Performance Problems (3.3.8)	Quality of data may be compromised.	Select experienced laboratory and maintain communication.

- The RPM and the risk assessor are familiar with standard analytical chemical procedures.
- Chemists are available and will be consulted for any significant problems or situations not covered in the manual.
- Reference books on environmental issues in analytical chemistry are currently available (ASTM 1979, Manahan 1975, Dragun 1988, Muntaueta1, Eds. 1990, Taylor 1987).
- Analytical quality assurance procedures are used in conjunction with and affect sampling quality assurance procedures, even though the discussion treats these procedures separately.

Exhibit 3-20 summarizes the importance of each analytical issue to risk assessment and lists suggested actions during the planning process. The issues are addressed individually in Section 3.3, including a statement of the issue, its effect on data quality for risk assessment, and how to anticipate and plan for potential problems.

3.3.1 CHEMICALS OF POTENTIAL CONCERN

The risk assessor should use preliminary data to identify chemicals of potential concern and determine any need to modify the sampling or analytical design.

EXHIBIT 3-21

MUNITION COMPOUNDS AND THEIR DETECTION LIMITS

Health Advisory	Acronym	Compound Name [1]	Detection Limit [2] (ppb)
*	HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	5.1
*	RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine	4.2
	—	Nitrobenzene	6.4
	TNB	1,3,5- Trinitrobenzene	5.9
**	DNB	1,3- Dinitrobenzene	9.1
	Tetryl	Methyl-2,4,6-trinitrophenylnitramine	4.4
*	TNT	2,4,6- Trinitrotoluene	6.3
**	2,4 DNT	2,4- Dinitrotoluene	2.3
	TAX	Hexahydro-1-(N)-acetyl-3,5-dinitro-1,3,5-triazine	
	SEX	Octahydro-1-(N)-acetyl-3,5,7-trinitro-1,3,5,7-tetrazocine	
**	2,6 DNT	2,6- Dinitrotoluene	5.1
*	2,4,5 TNT	2,4,5- Trinitrotoluene	
	2 Am DNT	2-Amino-4,6-dinitrotoluene	
	4 Am DNT	4-Amino-2,6-dinitrotoluene	
	2,4 DAmNT	2,4- Diamino-6-nitrotoluene	
	2,6 DAmNT	2,6- Diamino-4-nitrotoluene	
*	DIMP	Disopropyl-methylphosphonate	
*	TNG	Trinitrogylcerol (Nitroglycerin)	
*	---	Nitrocellulose	
**	DMMP	Dimethyl methylphosphonate	
**	NG	Nitroguanadine	

* Health advisory complete

** Health advisory in preparation (1990)

[1] Depending upon matrix and instrument conditions, these compounds may be chromatographable and tentatively identified as indicators of the presence of munitions during GC-MS library search procedures.

[2] Detection limits are provided where available. Specific compounds with complete health advisories are designated as target analytes with defined detection limits specified in a high performance liquid chromatographic method developed and provided by the U.S. Army Toxic and Hazardous Materials Agency.

Chemicals of potential concern are those chemicals with potential toxicological significance that may be present at the site. These chemicals may have defined toxicological thresholds for oral, inhalation, and dermal exposure pathways, may have target concentration levels set by the regulatory process, or may be of environmental concern. Many other chemicals may be present without affecting the level of risk to the exposed population. The need for risk assessment indicates that there is already some knowledge of contamination at the site. Based on available toxicological and site data, the risk assessor can recommend target chemicals (or chemical classes) for analysis and desired detection limits. For example, explosive chemicals are likely to be present at a former munitions site. Exhibit 3-21 presents data on munitions compounds, such as feasible detection limits and health advisory limits.

The information on chemicals of potential concern that may be obtained from historical data has been discussed earlier in this chapter. Information on industry-specific analytes is summarized in Exhibit 3-22 and detailed in Appendix II. Frequencies of occurrence of selected chemicals of potential concern at sites examined by EPA are included in Exhibit 3-12. If historical data are incomplete, a broad spectrum analysis should be performed on selected samples from each sampling location to provide necessary scoping information.

The risk assessor should inform the planning team about chemicals of potential concern at the site. Data on these chemicals should include exposure pathways, if known, concentrations of concern, and other pertinent information, particularly any requirement to distinguish specific states of the chemicals of potential concern. For example, some oxidation states of metals are more easily absorbed or are more toxic than others, and organically-substituted metals such as mercury are more toxic than elemental states. If these concerns are important, analyses that determine metal speciation rather than elemental analyses should be performed if available. Similarly, for organic compounds, degradation products or metabolites may be more toxic than the parent compounds. In this case, sampling procedures and analytical methods should include parent compound, degradation products, and metabolites of chemicals of potential concern.

EXHIBIT 3-22

SUMMARY OF MOST FREQUENTLY OCCURRING CHEMICALS OF POTENTIAL CONCERN BY INDUSTRY

COMPOUND	INDUSTRY 1	2	3	4	5	6	7
Acetone		X					
Aluminium							X
Ammonia		X	X		X	X	X
Ammonium Nitrate		X					
Ammonium Sulfate	X					X	
Anthracene					X		
Arsenic					X		
Benzene							X
Biphenyl					X		
Chlorine		X					
Chlorobenzene			X				
Chromium				X	X	X	
Copper					X		
Cyclohexane		X					
Dibenzofuran					X		
Dichloromethane			X	X			
Fomaldehyde					X		
Freon	X						
Glycol Ethers						X	
Hydrochloric Acid			X	X			
Lead	X						
Manganese	X						
Methanol	X		X				
Methyl Ethyl Ketone		X				X	X
Naphthalene					X		
Nickel				X			
Nitric Acid		X		X			
Pentachlorophenol		X			X		
Propylene							X
Sodium Sulfate	X	X	X	X		X	X
Sodium Hydroxide	X		X	X		X	X
Sulfuric Acid	X	X		X		X	X
Trichloroethene	X			X			
Toluene			X			X	X
Titanium Tetrachloride			X				
Xylene			X			X	X
1,1,1-trichloroethane	X			X			

KEY
1 = Battery Recycling
2 = Munitions/Explosives
3 = Pesticide Manufacturing
4 = Electroplating
5 = Wood Preservatives
6 = Leather Tanning
7 = Petroleum Refining

[1] Summarized from Appendix II.

3.3.2 LIBRARY SEARCH COMPOUNDS (LSCS) OR TENTATIVELY IDENTIFIED COMPOUNDS (TICS)

Specific analysis for compounds identified during library search can be requested.

The identification of an analyte is often based upon a search of a computerized library of mass spectra and is considered tentative when the analytical method does not treat the analyte as a target compound. The main steps in the assessment of LSCs are summarized in Exhibit 3-23. Organic compounds are initially identified in analyses by gas chromatography-mass spectrometry via computerized searching of the sample mass spectrum against compound libraries and through retention time/retention index matching. The confidence in identification can also be increased in a number of ways. The most direct way is to reanalyze the sample using a standard. A detailed examination of sample spectra for compound identification can be performed by an analytical chemist trained in mass spectral interpretation. Examination of historical data, industry-specific compound lists, compound identifications from iterative sampling episodes, and analyses performed by different laboratories may also increase the confidence in compound identification. Data review should confirm spectral identification.

EXHIBIT 3-23

STEPS IN THE ASSESSMENT OF LIBRARY SEARCH COMPOUNDS OR TENTATIVELY IDENTIFIED COMPOUNDS

Identification	• GC-MS analysis indicates the presence of a library search compound. • Incorporate retention time/retention index matching and use physical characteristics (boiling point or vapor pressure) to determine if identification is reasonable. • Examine historical data and industry-specific compound lists. • Re-analyze sample with an authentic standard.
Quantitation	• Assess known analytical response characteristics for similar compounds or similar compound classes. • Determine response characteristics by analysis of an authentic standard.

The concentrations of tentatively identified compounds can only be estimated, because corresponding standards have not been analyzed to calibrate the instrument. Further analyses should be requested by the RPM or risk assessor to quantitate toxic compounds that are tentatively identified in a broad spectrum analysis if authentic standards are available. The risk assessor should discuss the data requirements with a chemist to determine the appropriate analytical method.

Many compounds that appear as tentatively identified compounds during broad spectrum analyses belong to compound classes. Examples of compound classes are saturated aliphatic hydrocarbons and polycyclic aromatic hydrocarbons (PAHs). The risk assessor may be able to make a preliminary judgement of toxicity at the compound class level without a definitive identification of each compound present. For example, in a sample contaminated by gasoline, organics analysis would indicate a series of TICs as aliphatic hydrocarbons of increasing size. These may not be carcinogenic, and more precise identification may not be required. If a similar sample were contaminated with coal tar, larger hydrocarbons and a series of PAHs would be found during the analysis. The aliphatic hydrocarbons are not especially toxic, but the PAH compound class contains carcinogens and would be of greater concern.

3.3.3 IDENTIFICATION AND QUANTITATION

The type of detection or quantitation limit must be defined for reporting purposes; the sample quantitation limit (SQL) should be requested for risk assessment.

A risk assessor generally wants to confirm chemical identification first, and then determine the level of quantitation. This section summarizes the effects of detection limit and sample contamination considerations on the confidence in analyte identification and quantitation. Requirements are specified in Exhibit 3-24. When analytes have concentrations of concern approaching method detection limits, the confidence in both identification and quantitation is low. This case is presented in Exhibit 3-25. In addition, confidence in identification and quantitation as representative of site conditions is potentially diminished if the analytes are present as chemicals of potential concern from laboratory or field procedures. This section identifies analytes and cites situations in which this is most likely to occur.

EXHIBIT 3-24

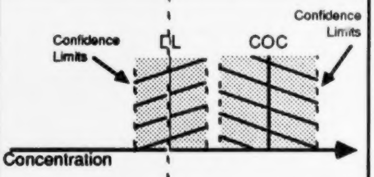
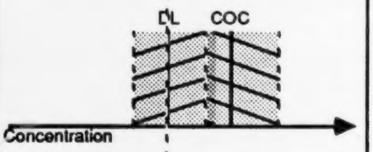
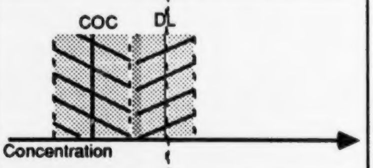
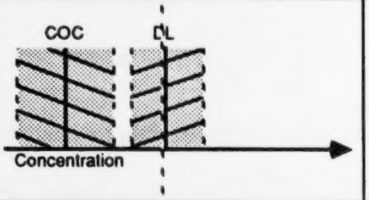
REQUIREMENTS FOR CONFIDENT IDENTIFICATION AND QUANTITATION

Identification	• Analyte present above the instrument detection limit. • Organic - Retention time and/or mass spectra matches authenic standards. Inorganic - Spectral absorptions compared to authenic standards. • Knowledge of blank contamination (if any).
Quantitation	• Instrument response known from analysis of an authentic standard. • Detected concentration above the limit of quantitation and within the limit of linearity (instrument response not saturated).

The first area of analytical consideration is confidence in the identification of chemicals of potential concern. Identification means that the chemical was detected in the environmental sample. Chemicals can be correctly identified at lower concentrations than are suitable for accurate quantitation. If lower quantitation limits are required for risk assessment purposes, a larger initial sample size may be processed, or the sample

EXHIBIT 3-25

COMPARISON OF DETECTION LIMIT WITH CONCENTRATION OF CONCERN TO SELECT AN ANALYTICAL METHOD

Relative Position of Detection Limit (DL) and Concentration of Concern (COC)	Consequence
 Confidence Limits DL COC Confidence Limits Concentration	Non-Detects and Detects Quantitatively Useable
	Possibility of False Positives and False Negatives
	Possibility of False Positives and High Possibility of False Negatives
	Non-Detects Not Useable Detects Quantitatively Useable Possibility of False Negatives

extract may be concentrated to a smaller final volume. The risk assessor should discuss these issues with an analytical chemist to determine the best approach. A further discussion of limits to quantitation is presented in Section 3.3.4.

To assure maximum confidence in the identification of an organic chemical contaminant, an instrumental technique such as mass spectrometry that provides definitive results is necessary. Although alternative techniques are available, GC-MS determination is the routinely available procedure for confident qualitative identification or confirmation of volatile and extractable organic chemicals of potential concern. The application of these techniques minimizes the risk of error in qualitative identification and measures chemicals of potential concern at environmental levels above the detection or quantitation limits listed in Appendix III. In cases where the necessary detection limit is too low to allow identification by mass spectrometry, more sensitive methods can be used.

The identification of inorganic chemicals is more certain. A reported concentration determined by atomic absorption (AA) or inductively coupled plasma (ICP) atomic emission spectrophotometry is considered evidence of presence at the designated level reported, provided there is no interference.

3.3.4 DETECTION AND QUANTITATION LIMITS AND RANGE OF LINEARITY

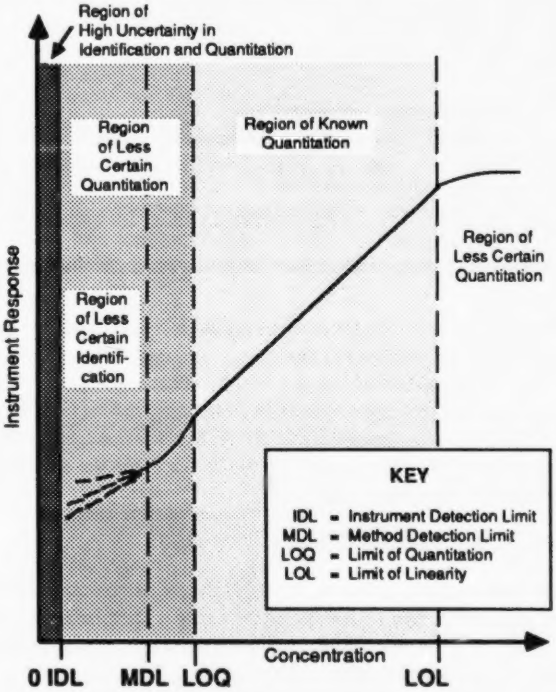
The closer the concentration of concern is to the detection limit, the greater the possibility of false negatives and false positives.

The wide range of chemical concentrations in the environment may require multiple analyses or dilutions to obtain useable data. Results from all analyses should be requested.

The following discussion is intended to provide the RPM and risk assessor with an understanding of the various ways that detection or quantitation limits can be reported. The term detection limit is frequently used without qualification. However, there are several methods for calculating detection limits. It is the responsibility of the RPM, in consultation with the risk assessor and the project chemist, to specify the nature of the detection limits that must be reported; it is the laboratory's responsibility to adhere to this requirement. If no requirement has been specified, then it is the responsibility of the laboratory to explicitly describe the types of the detection limits it reports. Detection limits can be calculated for the instrument used for measurement, for the analytical method, or as a sample-specific quantitation limit. The risk assessor should request that the sample quantitation limit be reported whenever possible. The term detection limit should be considered generic unless the specific type is defined. Exhibit 3-26 illustrates the relationship between instrument response and the quantity of analyte presented to the analytical system (i.e., a calibration curve).

EXHIBIT 3-26

THE RELATIONSHIP OF INSTRUMENT CALIBRATION CURVE AND ANALYTE DETECTION


Region of High Uncertainty in Identification and Quantitation
Region of Less Certain Quantitation
Region of Known Quantitation
Region of Less Certain Quantitation
Region of Less Certain Identification
Instrument Response
KEY
IDL - Instrument Detection Limit
MDL - Method Detection Limit
LOQ - Limit of Quantitation
LOL - Limit of Linearity
Concentration
0 IDL
MDL
LOQ
LOL

The following definitions are intended to provide the RPM and risk assessor with an understanding of the various methods for calculating detection limits, the terms used to describe specific detection limits, and the limitations associated with identification and quantitation of chemicals of potential concern at concentrations near specified detection limits. Understanding the different terms used to describe detection limits helps avoid reporting problems from confusion in their use. Exhibit 3-27 provides examples of calculations of the three most commonly reported types of detection limits.

Instrument detection limit

The instrument detection limit (IDL) includes only the instrument portion of detection, not sample preparation, concentration/dilution factors, or method-specific parameters. The IDL

EXHIBIT 3-27

EXAMPLE OF DETECTION LIMIT CALCULATION

IDL = 3.143 X S.D.[1] of replicate injections

Example: 100 ppb pentachlorophenol standard

If: S.D. = 5 ppb

Then: IDL = 3 X 5 ppb = 15 ppb

MDL = 3.143 X S.D. of replicate analyses (extraction and injection)

Example: 100 ppb pentachlorophenol spiked in sample producing average measured concentration of 50 ppb (not all analyte is recovered or measured)

If: S.D. = 18 ppb

Then: MDL = 3 X 18 ppb = 57 ppb

SQL = MDL corrected for sample parameters

Example: 100 ppb pentachlorophenol producing MDL of 57 ppb

If: Dilution factor = 10 (sample is diluted due to matrix interference or high concentrations of other analytes)

Then: SQL = 10 X 57 ppb = 570 ppb

---

[1] S.D. = Standard Deviation

is operationally defined as three times the standard deviation of seven replicate analyses at the lowest concentration level that is statistically different from a blank. This represents 99% confidence that the signal identified is the result of the presence of the analyte, not random noise. The IDL is not the same as the method detection limit, although the IDL is often the quantity reported for inorganic analyses.

Method detection limit

The method detection limit (MDL) is the minimum amount of an analyte that can be identified by using a specific method. The MDL can be calculated from the IDL by use of sample size and concentration factors and assuming 100% analyte recovery. This estimate of detection limit may be biased low because recovery is frequently less than 100%. MDLs are operationally determined as three times the standard deviation of seven replicate spiked samples run according to the complete method. Since this estimate includes sample preparation effects, the procedure is more accurate than reported IDLs. However, the evaluation is routinely completed on reagent water. As a result, potentially significant matrix interferences that decrease analyte recoveries are not addressed.

Sample Quantitation Limit

The sample quantitation limit (SQL) is the most useful limit for the risk assessor and should be requested whenever possible. An individual sample may require adjustments in preparation or analyses, such as dilution or use of a smaller sample aliquot for analysis due to matrix effects or the high concentration of some analytes. The reported sample quantitation limit is adjusted to reflect the sample-specific action. Therefore, sample quantitation limits will be the quantitation limits of interest for most samples.

In fact, for the same chemical, the SQL in one sample may be higher than, lower than, or equal to SQL values for other samples. In addition, preparation or analytical adjustments, such as dilution of the sample for quantitation of an extremely high level of one chemical, could result in non-detects for other chemicals included in the analysis even though these chemicals may have been present at trace quantities in the undiluted sample. The risk assessor should request results of both original and dilution analyses in this case. The reported SQLs will take into account sample characteristics, sample preparation, and analytical adjustments, so the SQLs are the most relevant quantitation limits for evaluating non-detected chemicals.

Contract Required Quantitation (Detection) Limit

The CLP utilizes a Contract Required Quantitation Limit (CRQL) for organics and a Contract Required Detection Limit (CRDL) for inorganics. This quantity is related to the SQL that has been shown through laboratory validation to be routinely within the defined linear ranges of the required calibration procedures. The use of CRQLs and CRDLs maintains the analytical requirements within performance limits that consider the laboratory variability using a variety of instruments. CRQLs are typically two to five times the reported MDLs and they generally correspond to the limit of quantitation (LOQ) described below.

Other quantitation measurements

In addition to the measurements described, two other terms relate to confidence in quantitation: the limit of quantitation and the limit of linearity.

The limit of quantitation (LOQ) is the level above which quantitative results may be obtained with a specified degree of confidence. At low analyte concentrations but above the method detection limit, the uncertainty in quantitation is relatively high. Although the presence of the analyte is accepted at 99% confidence, the quantity reported may be in the range of +/- 30%. To demonstrate a level at which confidence in quantitation is maximized, ten times the standard deviation measured for instrument detection is recommended as the LOQ (Borgman 1988). LOQ is more frequently used for organic compounds.

The limit of linearity (LOL) is the point at which the relationship between the quantity present and the instrument response ceases to be linear (Taylor, 1987). This point is at or above the upper end of the calibration curve. Instrument response usually decreases at this point, and the concentration reported is less than the amount actually present in the sample because of instrument saturation. For samples in which analyte concentrations exceed this amount, dilution is necessary to analyze the chemical within the linear range. However, dilutions correspondingly increase SQLs.

3.3.5 MEDIA VARIABILITY

This section relates method detection and general confidence in the analytical determination to specific media types. The medium (matrix) is the sample type to be analyzed for the presence of chemicals of potential concern. The impact of matrix interference on detection limits, identification, and quantitation is discussed. Examples include:

- Oil and hydrocarbons affecting GC-MS analyses.
- Phthalates and non-pesticide chlorinated compounds that can interfere with pesticide analyses.
- Iron spectral interference affecting ICP sample results.

The type of medium in which a chemical is present affects the potential sensitivity, precision, and accuracy of the measurement. Sharp distinctions occur in applying a single method to media such as water, oil, sludge, soil, or tissue. Medium or matrix problems are indicated by the presence of analytical interferences, poor recovery of analytes from the matrix, physical parameters such as viscosity (flow parameters), and particulate content that affect sample processing. Exhibit 3-28 shows the sources of uncertainty across media. Spiked environmental samples monitor the effect of these parameters on the recovery of target compounds from the matrix. Duplicates quantify the effect of these parameters on precision. The method must be chosen carefully if a difficult medium such as oily waste or soil is to be analyzed. Routine methods usually specify the medium or media for which they are applicable. The following discussion provides three examples of interferences and is not meant to be comprehensive.

Oil and hydrocarbons

The presence of appreciable concentrations of oil and other hydrocarbons may interfere with the extraction or concentration process. Also, even at low concentrations, oil in a sample usually produces a large series of chromatographic peaks that interfere with the detection of other chemicals of potential concern during gas chromatography. Any chemicals of potential concern that may elute concurrently are obscured by the hydrocarbon response and may not present a distinct spectrum. Also, hydrocarbons that are present in significant quantity are identified often as LSCs or TICs, potentially adding a large number of compounds for consideration by the risk assessor.

EXHIBIT 3-28

SOURCES OF UNCERTAINTY THAT FREQUENTLY AFFECT CONFIDENCE IN ANALYTICAL RESULTS

SOURCE OF UNCERTAINTY	DEGREE OF SIGNIFICANCE BY MEDIUM: SOIL	WATER	AIR	BIOTA	HAZARDOUS WASTE
SAMPLING					
Design	++	+	++		+
Contamination	++	+	+		
Collection	+	++	++		+
Preparation	++			++	
Storage		++	++		
Preservation		++		++	
LABORATORY					
Storage	++	++	++	++	
Preparation	++/+	++/+		+	++
Analysis	++		+	++	++
Reporting			+		++
ANALYTE-SPECIFIC					
Volatility	++	+	+		
Photodegradation		+	+		
Chemical Degradation	+	++			
Microbial Degradation	++	++			
Contamination	++		++		

KEY:
++ = Likely source of significant error or uncertainty.
+ = Potentially significant source of error or uncertainty.
++/+ = Magnitude of effect determined by examination of data.

During RI planning, the risk assessor should determine if there is a potential for hydrocarbon contamination, through knowledge of historical site use and examination of historical data. The sampling plan can either be directed to avoid sampling this matrix or the laboratory can be instructed to add cleanup protocols to the analysis, or to use a supplemental analysis for which the hydrocarbons are not interferences (e.g., electron capture detection for halogenated compounds).

Phthalates and non-pesticide chlorinated compounds

Phthalates interfere with pesticide analyses by providing an equivalent detector response to chlorinated compounds. Phthalates and non-pesticide chlorinated compounds are often present in greater concentrations than the pesticides of concern. Pesticide data are often required at low detection limits and, therefore, GC-MS analyses are not used for quantitation. In these cases, a gas chromatographic analysis using electron capture detection (ECD) can provide a wider useful range of detection and is more sensitive. The phthalates and chlorinated compounds can coelute with chemicals of potential concern, thereby obscuring the detection of target analytes and raising the analyte-specific quantitation limit. Phthalates and chlorinated compounds also produce additional peaks on the chromatogram that can be interpreted as false positive responses to pesticides. A second analysis using a different column provides an extra measure of confidence in identification. Alternatively, sample extracts from positive analyses can be further concentrated for confirmation by GC-MS if concentrations of analytes are sufficient.

Iron

Large quantities of iron in a sample affect the detection and quantitation of other metallic elements analyzed by ICP/atomic emission spectroscopy at wavelengths near the iron signals. The strong iron response overlaps nearby signals, thereby obscuring the results of potentially toxic elements present at much lower concentrations. An interference check sample for ICP analyses monitors the effect of such elements. High concentrations of iron are analyzed with low concentrations of other metals in these samples to indicate if interference may have been present which affected the certainty of detection of metals at lower concentrations. Data are usually qualified as underestimated when spectral interferences are observed. The risk assessor or RPM can request an interference check.

3.3.6 SAMPLE PREPARATION

Several factors contribute to the effect of sample preparation on the analytical data. These factors include sample matrix, desired detection limit, extraction solvent, and whether the analysis is performed in the field or in a fixed laboratory. In addition, parameters such as turnaround time may preclude the use of some sample preparation alternatives.

An extraction method must be able to release the compounds of concern from the sample matrix. For example, organic solvents will extract non-polar organic compounds from water. Polar and ionic compounds may require additional techniques for extraction from water. The choice of solvent is also critical to the extraction efficiency. Methanol would be expected to extract a larger quantity of volatile organic material from soils or sediments than from water. For inorganic analyses, the matrix may have to receive additional acidification to dissolve metal salts that have precipitated from the solution.

Sample preparation procedures for volatile organic compounds include head-space and purge-and-trap. Extraction alternatives for the analysis of less volatile (extractable organics) organic chemicals include separatory funnels, soxhlet extraction apparatus, continuous liquid-liquid extractors, and solid phase cartridges. Strengths and weaknesses of each of these preparation procedures are described in Exhibit 3-29.

Prior to elemental analysis by flame atomic absorption or ICP atomic emission spectrophotometry, the sample matrix is usually digested in concentrated acid to release the metals for introduction into the instrument. The selection of the acid for digestion influences the detection limit.

- If digestion is not used, the sample measurement corresponds to a determination of soluble metals rather than total metals. If soluble metals have a greater toxicological significance, this difference may be important to the risk assessment process.
- If the sample is filtered in the field or the laboratory before digestion, any metals associated with particulates are removed before analysis. If particulates are an exposure pathway in the risk assessment, the risk would be underestimated.

The analytical request must specify if the sample is to be filtered and whether or not it is to be digested (to measure soluble metals). Unless otherwise specified, samples are usually digested but not filtered.

3.3.7 FIXED LABORATORY VERSUS FIELD ANALYSES

Field instruments are usually divided into three classes:

- Field portable instruments that can be carried by a single person.
- Field transportable instruments that can be moved and used in the field or in a mobile laboratory.
- Mobile laboratory instrumentation that is installed in a trailer for transport to a site.

Use of the CLP or other fixed laboratory sources is most appropriate for broad spectrum analysis, or confirmatory analysis.

Analyte-specific field screening and monitoring tests are currently available and fall in the category of field portable or transportable instruments. Chemical field test kits, ion-specific probes, and immunoassays have provided semi-quantitative results free of significant matrix interference. The data can be used quantitatively if confirmed by additional types of quantitative analysis. Different tests can be chosen to examine organic compounds, inorganic analytes, nutrients, or water quality indicators. Field instruments are also frequently used to indicate the presence of contamination. For example, they may provide a total vapor concentration. These analyses can be used to identify critical locations and to modify sampling plans in the field to determine the extent of contamination. Consequently, for some sites, these procedures can provide data that are directly useful to the risk assessment. The number of samples needed and turnaround requirements must be considered when evaluating field screening data as a source for risk assessment.

Data should be available from a broad spectrum analysis from each medium and exposure pathway to minimize the potential for false negatives.

EXHIBIT 3-29

COMPARISON OF SAMPLE PREPARATION OPTIONS

Fraction & Matrix	Preparation	Strengths	Weaknesses
Volatile Soil/Water	Head-space	Rapid, simple, potentially automated and minimal interferences if standards are prepared using sample media to minimize the effects of ionic strength variability between samples and standards.	Qualitative identification, comparison of concentration possible but quantitative standardization is difficult, especially true for complex matrix (e.g., particulates and clay in soil). No mechanism for concentration. Application and sensitivity are very analyte-specific.
	Purge/Trap	Generally recommended for this analysis (comparabilities); can be automated; broadly applicable and allows concentration factor; good recoveries across analyte list.	Sacrifice of either highly volatile analytes or inadequate purge of low volatility analytes; dependent on purge and trap parameters.
		High precision and recoveries for waters.	Soils have variable response dependent on soil characteristics. Efficiency of soil purge is not monitored.
Extractable Organics in Water	Separatory Funnel	Relatively rapid processing and low set-up costs; relatively high PAH recovery.	Generally low recovery of target analytes, high potential for matrix problems, poor method precision.
	Continuous Extraction	Minimal matrix problems; generally higher analytical precision and high phenol recoveries; overall high extraction efficiency (accuracy).	Lower recovery of PAH and phthalates (especially higher MW); time-consuming procedure and high initial set-up costs; more potential for contamination.
	Solid Phase Extraction	Very rapid, simple technique; samples can be extracted in the field for laboratory analysis; potentially low MDL in a clean matrix.	Procedure has limited available performance data. Presence of interference and matrix problems can affect extraction efficiency and data quality. Each batch of extraction medium must be tested for efficiency by recovery of standards, preferably in the same matrix. Breakthrough (loss) at high sample concentrations.
Extractable Organics in Soil	Sonication	Rapid sample preparation; relatively low solvent requirement; good efficiency of analyte recovery/matrix exposure to solvent.	Labor intensive, constant attention to procedure. Relatively high initial cost. Methylene chloride/acetone solvent mixture results in many condensation products and often in method blank contamination.
	Soxhlet Extraction	Relatively routine requirement for direct analytical support; relatively good exposure of sample to solvent if sample texture appropriate. Relatively low initial cost.	Relatively high operating cost-replacement apparatus, solvent, for some matrices may not provide efficient sample/solvent contact (e.g., channeling, very slow sample output).
Inorganics	Acid Digestion	Promotes ionic speciation; dissolves particulates, provides results for total metals.	Some compounds are acid insoluble; digestion may promote interference effects.
		Isolates dissolved metals species.	Filtration problems in field. Does not provide a total metals assay. Is an extra step in sample collection.
	0.45 um Membrane Filtration	No preparation required, provides results for dissolved metals.	Particulates affect sample introduction.

Rugged versions of fixed laboratory instrumentation, such as X-Ray fluorescence spectrometers (XRF) and gas chromatographs, can often be installed in trailers if adequate ventilation and power supplies are available. Therefore, analytical methods that have traditionally been restricted to off-site laboratories can now be employed in the field. In addition, the quality of field instrumentation has improved steadily allowing for better measurements at the site. Through the use of field instrumentation, samples can be analyzed immediately or with short holding times with no shipping and storage requirements. It is recommended that 10% of field analyses be confirmed by fixed laboratory analyses.

Fixed laboratory analyses are particularly useful for conducting some broad spectrum analyses for target compounds to avoid the possibility of false negatives. They generally provide more information for a wider range of analytes than field data. Fixed laboratory data sources are generally more reliable than field screening or field analytical techniques. Mass spectrometry combined with gas chromatography provides greatly enhanced abilities for compound identification and is the recommended means of identification for organic analyses. For inorganics, AA spectroscopy or ICP emission spectroscopy should be used for reliable identification of target compounds. Once the broad spectrum analysis and contaminant identification has occurred, other methods may be employed that better quantitate specific analytes of concern and that are less expensive. Other methods may also offer lower detection limits.

Characteristics that should be considered in the selection of field or fixed laboratory instrumentation include: turnaround time, detection and identification ability of the instruments, precision and accuracy requirements of the measurements, and operator qualifications. Exhibit 3-30 compares the characteristics for field and fixed laboratory analyses. The risk assessor and RPM should consider the available options and make a choice of analysis based on method parameters, turnaround time, and cost, as well as other data requirements pertinent to risk assessment needs (e.g., legal defensibility). Exhibit 3-31 compares the strengths and weaknesses of field and fixed laboratory analyses.

Field instruments usually produce data in a shorter time because sample shipment is not required and analytical methods are often streamlined. The fixed laboratory instruments usually have lower detection limits because of the stability of the installation and less likelihood of contamination from site chemicals of potential concern. However, if a fixed laboratory is using GC-MS methods and the field analyses are using GC methods, then the field analyses will have lower detection limits. Because mass spectrometers can now be installed in trailers for transport to a site, both fixed laboratory and field installations can provide good organic analyte identification. Identification by high resolution mass spectrometry is still restricted to the fixed laboratory, however.

Field methods can produce legally defensible data provided that appropriate quality control and documentation are available.

The precision and accuracy of individual measurements may be lower in the field than at a fixed laboratories, but the quicker turnaround and the possibility of analyzing a larger number of samples at the same cost may compensate for this factor. A final consideration is the qualifications of operators in the field. The RPM, in consultation with chemists and quality assurance personnel, should set proficiency levels required for each instrument class and review the qualifications of personnel proposed as instrument operators for compliance with these specifications.

EXHIBIT 3-30

CHARACTERISTICS OF FIELD AND FIXED LABORATORY ANALYSES

CHARACTERISTIC	FIELD ANALYSIS	FIXED LABORATORY ANALYSIS
Prevention of false negatives	Immediate analysis means volatiles not lost due to shipment and storage.	More extensive sample preparation available to increase recovery of analytes.
Prevention of false positives	No sample to sample contamination during shipment and storage.	Contamination by laboratory solvents minimized by storage away from analytical system.
Analytical Turnaround Time	Data available immediately or in up to 24-48 hours (additional time necessary for data review).	Data available in 7-35 days unless quick turnaround time requested (at increased cost).
Sample Preparation	Limited ability to prepare samples prior to analysis.	Samples can be extracted or digested, thereby increasing the range of analyses available.
Cost of Acquisition	Cost is relatively low for individual organics and inorganics analyses. (More samples may be collected for better precision and accuracy.)	Cost is relatively high. (Individual analyses provide better precision and accuracy.)

EXHIBIT 3-31

STRENGTHS AND WEAKNESSES OF FIELD AND FIXED LABORATORY ANALYSES

ANALYSIS[1]	STRENGTHS	WEAKNESSES
Field XRF (Metals)	Extremely high volume sampling and analysis; compatible with sophisticated sampling and data handling software; detection limit may be above laboratory instrument values but applicable to specific site levels of interest.	Confirmation technique recommended. Comparability may require external standardization of calibration because quantitation is based on soil surface area vs. a soil volume. Results often lower than from AA analyses.
Field GC	Rapid analysis supporting high volume sampling for variety of volatile and extractable organic target compounds (includes pesticide/PCB). Minimization of sample handling variability and data quality indicators comparable to fixed laboratory methods.	Requires prior site knowledge to assure applicability to specific conditions (e.g., soil gas may not be appropriate for investigation in sandy area). Confidence in identification is matrix- and site-specific and highly variable depending on sample complexity. Confirmation technique recommended.
Mobile Laboratory XRF, AA (Metals)	Combines the high volume sample capacity of field analyses with the detection limits, data quality and confidence associated with laboratory analyses.	Requires significant resources, time, and personnel to transport, maintain and operate. Generally most appropriate at high volume sites, especially remote.
Mobile Laboratory Luminescence	Rapid survey of analytes that routinely require sample preparation (e.g., polynuclear aromatics and PCBs). Detection limits can be adjusted within limits to site-specific concentrations of concern.	Technique has had minimal use in EPA site investigation. Comparability may be an issue and require extensive confirmation analyses.
Mobile Laboratory GC, GC-MS	Combines high volume capacity of field analyses with increased confidence in identification (GC-MS) or improved data quality (GC). GC methods may be identical to laboratory procedures but quality is intermediate due to site conditions (e.g., temperature, humidity and power requirements).	Same weaknesses as for mobile laboratory inorganics. An additional weakness is the increased training requirements and decreased availability of experienced GC-MS operators for totally independent system operation. Possibiity of site contamination and cross-contamination.
Fixed Laboratory XRF, AA, ICP (Metals - Routine Available Methods)	Highest comparability and representativeness. Data quality, including detection limits, generally predictable. Efficient match of analyses required to instrument (e.g., multiple analyses run simultaneously by ICP).	Slow delivery of data, increased documentation requirement due to the number of participants - relatively high sample cost.
Fixed Laboratory GC & GC-MS (Organics - Routine Available Methods)	Highest comparability and representativeness. Necessary confirmation of qualitative identification. Data quality and detection limits generally predictable. In depth analysis and sample archives for follow-up testing.	Same weaknesses as for fixed laboratory metals. Analyte-specific performance.

[1] ICP = Inductively Coupled Plasma Spectroscopy. Graphite AA = Graphite Furnace (electrothermal) Atomic Absorption Spectroscopy. Flame AA = Flame Atomic Absorption Spectroscopy. ICP-MS = Inductively Coupled Plasma-Mass Spectrometry. XRF = X-Ray Fluorescence. GC = Gas Chromatography. GC-MS = Gas Chromatography-Mass Spectrometry. AA = Atomic Absorption Spectroscopy.

EXHIBIT 3-31

STRENGTHS AND WEAKNESSES OF FIELD AND FIXED LABORATORY ANALYSES (continued)

ANALYSIS [1]	STRENGTHS	WEAKNESSES
ICP	Simple, automated, extremely rapid. Can assay metals simultaneously. Can detect ppb levels.	Subject to salt or iron interferences. Lacks detection capability at low levels. Not suitable for less than 20 ppb Arsenic, Lead, Selenium, Thallium, Cadmium, Antimony. Requires background and interelement correction.
Graphite AA	Simple, automated. Can assay most metals. Can assay low level metals. Can detect ppb levels.	Lower precision and accuracy unless methods of standard additions used. Method is time-consuming. Requires background correction. Requires matrix modifiers. Graphite tube requires replacement frequently. Subject to spectral interferences.
Flame AA	Simple, rapid, very suitable for high concentration sodium and potassium assays. Commonly used and rugged.	Not as sensitive as graphite AA. Salts can interfere. Limited by lamp capabilities. Detects ppm levels.
ICP-MS	Rapid. Can detect low levels. Accurate.	Subject to isobaric molecular and ion interferences. Nebulization, transport process, and memory physical interferences occur. Method is relatively new and is expensive. Specialized training is required.
ICP-Hydride	Rapid. Can detect low levels of Antimony, Arsenic, Selenium. Hydride formation eliminates spectral interferences.	Dependent on analyte oxidation state. Especially sensitive to copper interference. Method is relatively new. Specialized training is required.

[1] ICP = Inductively Coupled Plasma Spectroscopy. Graphite AA = Graphite Furnace (electrothermal) Atomic Absorption Spectroscopy. Flame AA = Flame Atomic Absorption Spectroscopy. ICP-MS = Inductively Coupled Plasma-Mass Spectrometry. XRF = X-Ray Fluorescence. GC = Gas Chromatography. GC-MS = Gas Chromatography-Mass Spectrometry. AA = Atomic Absorption Spectroscopy.

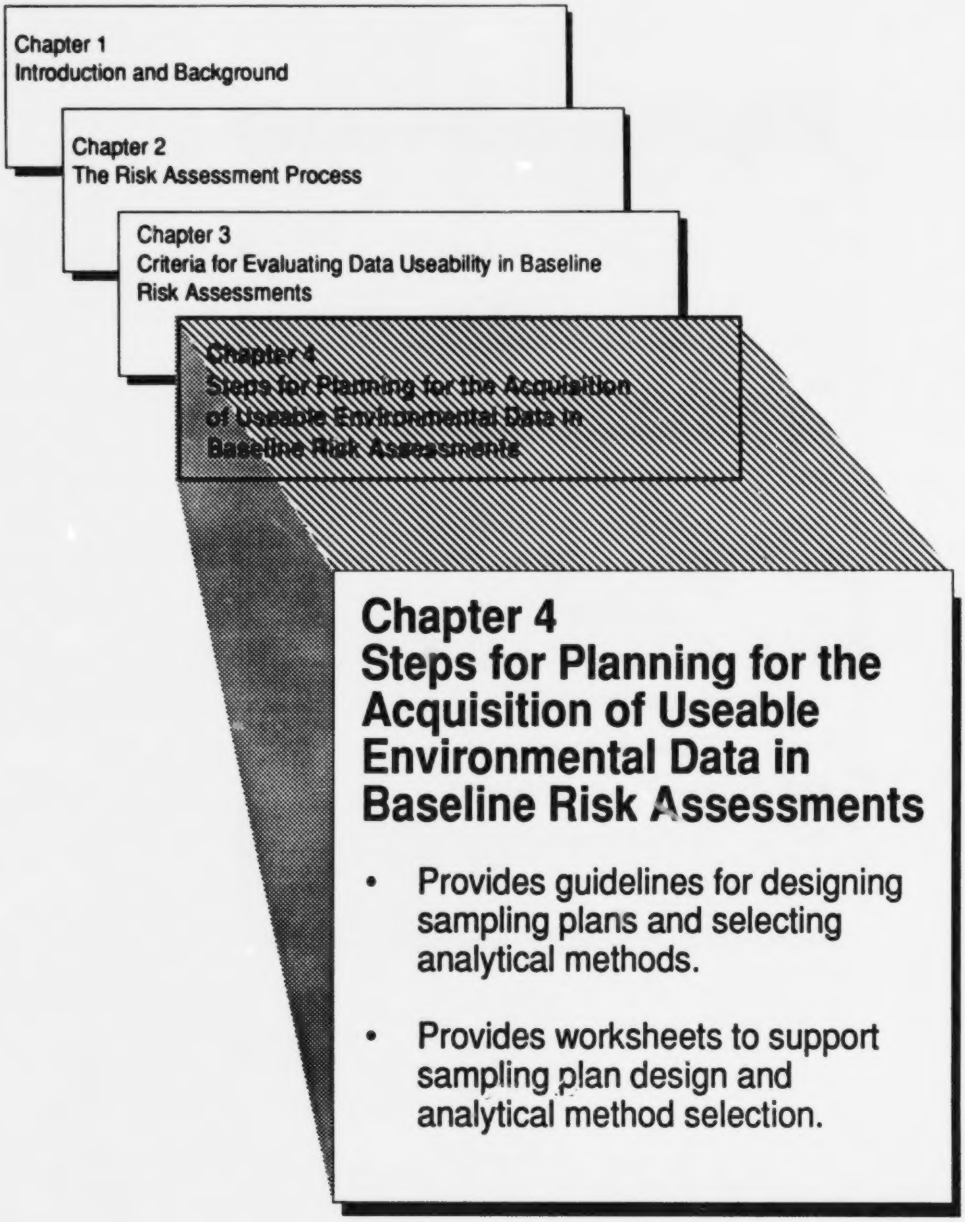
3.3.8 LABORATORY PERFORMANCE PROBLEMS

The RPM should be aware of problems that occur during laboratory analyses, even though the resolution of such problems will usually be handled by the project chemist. This section discusses common performance problems and explains how to differentiate laboratory performance problems from method performance problems.

Communication with the chemist ensures proper laboratory selection and minimizes laboratory and/or methods performance problems that occur during the analysis of environmental samples.

Laboratory performance problems may occur for routine or non-routine analytical services and can happen with the most technically experienced and responsive laboratories. Laboratory problems include instrument problems, personnel inexperience or insufficient training, and overload of samples. Issues that may appear to be laboratory problems, that are actually planning problems, include access to standards, unclear requirements in the analytical specifications, difficulty in implementing non-routine methods, and some sample-related problems. Another problem for the RPM may be a lack of laboratories with appropriate experience or available capacity to meet RI analytical needs.

- Instrument problems can be revealed by requiring a unique identifier for each instrument in the laboratory that is reported with the analyses. Instrument blanks and calibration and performance standards should be specified in the analytical method to monitor the performance of each instrument.
- Some degradation in data quality may appear when new personnel are utilized or when the sample load for a laboratory is too high. The contributing personnel for each analysis should be identified clearly in laboratory records and reports, and required qualifications of personnel should be documented in contracts.
- Sample and method problems can be distinguished from laboratory problems because they are usually not associated with a specific instrument or analyst.



Chapter 1
Introduction and Background

Chapter 2
The Risk Assessment Process

Chapter 3
Criteria for Evaluating Data Useability in Baseline Risk Assessments

Chapter 4
Steps for Planning for the Acquisition of Useable Environmental Data in Baseline Risk Assessments

Chapter 4
Steps for Planning for the Acquisition of Useable Environmental Data in Baseline Risk Assessments

- Provides guidelines for designing sampling plans and selecting analytical methods.
- Provides worksheets to support sampling plan design and analytical method selection.

ACRONYMS FOR CHAPTER FOUR

BNA	Base/Neutral/Acid
CLP	Contract Laboratory Program
CV	Coefficient of Variation
DQO	Data Quality Objective
GC	Gas Chromatography
GPC	Gel Permeation Chromatography
MS	Mass Spectrometry
PCB	Polychlorinated Biphenyl
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RPM	Remedial Project Manager
SAS	Special Analytical Services
VOA	Volatile Organics Analysis

4.0 STEPS FOR PLANNING FOR THE ACQUISITION OF USEABLE ENVIRONMENTAL DATA IN BASELINE RISK ASSESSMENTS

This chapter provides planning guidance to the RPM and risk assessor on designing an effective sampling plan and selecting suitable analytical methods to collect environmental analytical data that will be optimally useable in baseline risk assessments. The first section of the chapter describes the process of selecting an appropriate sample design strategy and developing a sampling plan that is devised to resolve the four fundamental risk assessment decisions presented in Chapter 3:

- What contamination is present and at what levels?
- Are site concentrations sufficiently different from background?
- Are all exposure pathways identified and examined?
- Are all exposure pathways fully characterized?

A Sample Design Selection Worksheet is used as a data collection and decision-making tool in this process. Guidance for evaluating alternative sampling strategies and designing statistical sampling plans is included.

The second section of the chapter provides detailed guidance on selecting the methods for analyzing samples collected during the RI. A Methods Selection Worksheet is used to compile the list of chemicals of potential concern and determine analytical priorities so that the most suitable combination of methods is selected.

The risk assessor or RPM, in consultation with other technical experts, will usually complete several worksheets, representing different media, exposure pathways, potential sampling strategies, chemicals of potential concern, and analytical priorities, in order to compile sufficient information to communicate basic risk assessment requirements to the RPM so that these requirements will be addressed in the SAP. Section 4.1 explains how to complete the Sample Design Selection Worksheet and how to obtain summary information from the worksheets to support the final decision on the RI sample design. Section 4.2 gives instructions for completing the Method Selection Worksheet and tells how to use worksheet information to select the appropriate analytical methods for the RI.

The final selection of sampling plans and analytical methods is based on the specification of the performance measures discussed in this chapter. These measures are data quality indicators (DQIs) that are components of the data quality objectives (DQOs) developed by the RPM for the total data collection and evaluation effort.

4.1 Strategies for designing sampling plans

This section provides guidance for evaluating the necessity of alternative sampling strategies and designing a statistical sampling plan. The objective is to determine a strategy that collects data representative of conditions at the site and is within resource limitations. The data must have acceptable levels of precision and accuracy, obtain minimum required levels of detection for chemicals of potential concern, and minimize the probability of Type I and Type II errors. Meeting these objectives involves optimizing the precision of concentration estimates and the power to detect differences between site and background levels. To accomplish these objectives, the RPM can:

- Increase the number of samples.
- Improve the sample design.
- Improve the efficiency of statistical estimators.

Increasing the number of samples may increase initial costs to a varying degree, depending on whether fixed or field analytical methods are used for analysis, but is necessary in certain situations (see Section 4.1.2). The sample design can often be improved by stratifying within a medium to reduce variability or by selecting a different sampling approach, such as a geostatistical estimation procedure termed "kriging." Improving the efficiency of the statistical estimators involves specifying the type of data distribution if parametric procedures are being used, or switching from nonparametric to parametric if distributional assumptions can be made. By reducing sample variability through increasing the number of samples, costs are often reduced in clean-up efforts.

Exhibit 4-1 is a Sample Design Selection Worksheet, structured to assist design selection for the most complex environmental situation, which is usually soil sampling. The worksheet contains the elements needed to support the decision on RI sample design. The RPM and risk assessor should use this worksheet, or use it as a model to create one specifically suited to their needs, to design a site sampling plan that will meet the data useability requirements of the risk assessment. To use the worksheet, initially assume a stratified random design and complete the worksheet on this basis for each medium and exposure pathway at the site. Once completed, this initial set of worksheets can be modified to assume alternative sampling strategies. Completion of a set of worksheets (i.e., a worksheet for each medium and exposure pathway at a site, based on a single sampling strategy) specifies the total number of samples to be taken for an exposure pathway and sample breakdown according to type (i.e., site environmental samples, quality control samples, background samples).

EXHIBIT 4-1
SAMPLE DESIGN SELECTION WORKSHEET

I. Pathway Medium and Design Alternative	A. Exposure pathway *(specify)*:	B. Medium *(specify)*:	C. Design alternative: Stratified Random ☐ Other ☐ *(specify)* ____________

II. Contaminant Characteristics for Medium	A. Chemicals of Potential Concern	B. Frequency of Occurrence (%)	C. Est. Concentration		D. Coefficient of Variation (C.V.)
			Avg (ppb)	Max (ppb)	

E. Chemical distribution: ☐ Homogeneous ☐ Heterogenerous *(define potential strata)*

III. Performance Measures	Stratum *(specify)*: ⇨				
	A. Confidence level *(percent)*				
	B. Power *(percent)*				
	C. Minimum detectable relative difference *(percent)*				
	D. Measurement error precision *(confidence limit)*				
	E. Completeness for critical samples				
	F. Other performance measures *(specify)*:				

IV. Number of Samples	A. No. of Environmental Samples:				
	B. Quality Control Samples: No. of Duplicates				
	No. of Blanks				
	Total Samples for Stratum:				
	Contamination concerns, if any *(specify)*:				
	C. No. of background samples:				
	D. Total no. of samples for pathway/medium *(sum of strata plus background)*: ☐				

EXHIBIT 4-1
SAMPLE DESIGN SELECTION WORKSHEET
(continued)

V. Modifying Sample Design	A. Hot spots known?	☐ ☐	No Yes *(describe, include estimate of radius)*:
	Probability of missing hot spot:	☐	
	B. Historical data?	☐ ☐	No Yes *(specify design)*:
	Are current and historical data sets comparable?	☐ ☐	Yes No (CONSIDER MODIFYING SAMPLE DESIGN)
	C. Resource issues?	☐ ☐	No Yes *(specify issues and potential design modification)*:
	D. Other issues *(specify)*:		

The remainder of this section is a step-by-step guide to completing the Sample Design Selection Worksheet. Chemicals of potential concern listed on the Sample Design Selection Worksheet should be the same as those used for the Method Selection Worksheet (Exhibit 4-6).

4.1.1 COMPLETING THE SAMPLE DESIGN SELECTION WORKSHEET

Use of the Sample Design Selection Worksheet will help the RPM or statistician to determine an appropriate sampling design.

Step I - Pathway, medium and design alternatives

Step IA - Specify exposure pathway.

In this worksheet space, enter the identifier for the exposure pathway to be sampled.

Step IB - Specify medium.

The worksheet is specific to a particular medium within a pathway, so that sample design alternatives will be examined independently for each medium in the exposure pathway. Enter the name of the medium on the worksheet (e.g., soil, sediment, ground water, surface water, air, biota).

Step IC - Identify sample design alternatives.

For planning purposes, first assume a stratified random design. This assumption facilitates the discussion of performance measures and sample size. For systematic grid and geostatistical designs, the basic planning concepts are the same but the calculation and setup procedures are significantly more complex. Detailed discussions of the advantages and disadvantages of classical and geostatistical designs are available (Borgman and Quimby 1988 and EPA 1989c). An overview of these procedures is provided here.

> *While other designs may be as appropriate in many cases, stratified random or systematic sampling designs are always acceptable.*

Sampling procedures used in environmental sampling may be unbiased or biased. Two alternative statistical models are available for use in unbiased sample evaluation and hypothesis testing: the classical model and the geostatistical model. The classical model is based on random or stratified random procedures and the geostatistical on optimizing co-variance. Systematic grid sampling can be utilized by either model. Biased, or purposeful designs require the use of different approaches to planning and evaluation.

- Classical model: The classical model using a stratified random sampling design is appropriate for use in sampling any medium. This design produces unbiased estimates and is always acceptable, although for some situations other designs are more effective or efficient. A stratified random design provides the RPM and risk assessor with great flexibility. If the nature and extent of the exposure areas are not yet well defined, a pilot study can be conducted and the results included in the final design. The data can be averaged for any area of concern using the samples of interest without losing the advantages of the stratified random sampling probability model. This model is the basis for calculating confidence levels, power, and minimum detectable differences. The classical approach is not subject to judgmental biases, and produces known estimates and recognized statistical measures and guidelines because of the simplicity of assumptions.
- Geostatistical model: Geostatistical techniques are good for identifying hot spots and reasonable maximum exposure (RME) site characterization. These techniques require complex judgmental and calculation procedures. Even with the use of available computer programs, a statistician should be consulted since different approaches to estimating key parameters can produce different estimates.
- Systematic grid sampling: Systematic grid sampling procedures are good for identifying unknown hot spots and also provide unbiased estimates of chemical occurrence and concentration (Gilbert, 1987). Systematic sampling can be used in geostatistical or classical estimation models. Special variance calculations are required to estimate confidence limits on the average concentration. Systematic sampling is especially powerful for complete site or exposure area characterization when the sampled area is known to be heterogeneous. However, a large number of samples are often required.

Step II - Specify contaminant characteristics for medium.

Sample design selection and the determination of the required number of samples to meet performance objectives are dependent on the spatial and temporal variation of contaminants in the medium at the site. This variation is a function of fate and transport properties, in addition to use and disposal practices, and any unusual physical site characteristics. Key measures of contaminant characteristics to be recorded include: frequency of occurrence, average and maximum concentrations, coefficient of variation, and chemical distribution. Estimates of key characteristics can be derived from historical site data, pilot studies and/or reported data from Superfund site databases such as CLP Analytical Results Database (CARD) and the Statistical Database (STAT). These databases have analytical results for over 8,900 sites across 10 Regions. A weighted approach to using existing data should be adopted if any of the sources are considered more (or less) reliable.

Step IIA - Identify chemicals of potential concern.

Based on historical data, list the known or suspected contaminants as chemicals of potential concern.

Step IIB - Estimate frequency of occurrence.

Estimate the frequency of occurrence of each chemical of potential concern on a sample basis and enter this number on the worksheet. The frequency of occurrence is the percent of samples in which the contaminant was identified, and can be calculated only if sample data are available for the site or exposure area. An estimate of frequency of occurrence can also be made as an exposure area estimate based on fate and transport or disposal. Estimates of exposure area occurrence frequency:

- Over 50% - should cause few chemical identification problems and the probability of false negatives will be low.
- Below 10% - may be missed by less rigorous sample designs.
- Between 10% and 50% - the nature of the distribution will determine the probability of a false negative.

Step IIC - Record estimated average and maximum concentrations.

For each chemical of potential concern, record the average and maximum estimated concentration obtained from historical data or data from similar sites. This information will indicate that the concentration of concern, method detection limit, and/or background levels may be close and that the detection of statistically significant differences will be difficult. This would cause an increase in the number of samples required to meet performance objectives. Conversely, high average concentrations and maximum concentrations potentially indicate a large coefficient of variation, which would also require an increased number of samples. Exhibit 3-12 shows frequency of occurrence of analytes and median coefficients of variation for selected contaminants at Superfund sites.

Step IID - Estimate coefficient of variation.

Estimate the coefficient of variation for each analyte from prior information or from the guidelines given in Chapter 3.

- Coefficients below 20% indicate little variability in the concentrations of the chemical of potential concern.
- Coefficients over 40% indicate greater variability, and potentially require a large number of samples to meet performance objectives.

Step IIE - Classify chemical distribution.

Once the contaminant characteristic table is completed, make a judgment as to whether the distribution of contaminant characteristics can be classified as homogeneous or heterogeneous and mark this on the worksheet. Chemical distribution can be classified by answering the question: Is there similarity or dissimilarity in properties between characteristics that have been predicted across the compounds of potential concern at the site?

- If the distribution is heterogeneous (dissimilar properties) determine the basis for the differences and consider stratification. Define potential strata on the worksheet. An example of a heterogeneous distribution is one where many contaminants occur at the site at similar frequencies and one contaminant occurs at a very different frequency.
- If the distribution is homogenous (similar properties), stratification is not needed.

Step III - Select performance measures

During planning, propose and discuss quantitative performance measures based on performance objectives for completeness, comparability, representativeness, precision, and accuracy. Performance measures are specified as minimum limits for each stratum. Based on the coefficients of variation of the analyte concentrations, these limits will determine the numbers of samples required. The actual values or objectives are determined by the level of acceptable uncertainty including that associated with hot spot identification. Recommended minimum criteria for statistical performance measures associated with risk assessment variability, confidence level, power, and minimum detectable difference are specified in Steps IIIA, IIIB, and IIIC.

Five basic performance measures are employed in the evaluation of statistical sampling designs. Three of these measures, confidence level, power, and minimum detectable difference, are related to sample variability. Measurement error is the fourth performance measure, and completeness for critical samples is the fifth. These performance measures are discussed in the following sections.

Step III A-C Set minimum acceptable limits for confidence level (IIIA), power (IIIB), and minimum detectable relative difference (IIIC).

Confidence level, power, and minimum detectable relative difference are three measures of sample design precision. These measures are ultimately determined by the coefficient of variation of chemical concentration and the number of samples. Each measure is briefly defined as follows:

- Confidence level: One hundred minus the confidence level is the percent probability of taking action when no action is required (Type I error or false positive).
- Power: One hundred minus the power is the percent probability of not taking action when action is required (Type II error or false negative).
- Minimum Detectable Relative Difference: Percent difference required between site and background concentration levels before the difference can be detected statistically.

For risk assessment, power and the ability to detect differences between site concentration levels compared to background levels are critical. Given a coefficient of variation, the required levels of certainty, power, and minimum detectable differences significantly affect the number of samples. The following table illustrates the effect when the C.V. is equal to 25% (EPA 1989c):

Confidence	Power	Detectable% Difference	No. of Samples
90%	90%	10	42
90%	90%	20	12
80%*	90%	20	8
80%	80%	10	19
80%	80%	20	5
80%*	90%	40	3

*The minimum recommended performance measures for risk assessment purposes are: confidence (80%) and power (90%)

It is important to note that the number of samples required to meet confidence and power requirements will be very low if the acceptable minimum detectable difference is larger; that is, if site contamination is easily discriminated from background levels.

Step IIID - Determine required measurement error precision.

The major field quality control samples of importance to the precision of measurement error are field duplicates and blanks.

Duplicates provide an estimate of total measurement error variance, including variance due to sample collection, preparation, analysis, and data processing. They do not discriminate between-batch error variance. If the duplicate is collocated, contaminant sample variation caused by a heterogeneous medium is also included in the measure. The precision of the measurement error estimate is subject to the number of duplicates on which the estimate is based. Exhibit 4-2 gives the estimated precision of the measurement error based on the number of duplicate pairs. With three duplicates, the true measurement error variance could be as much as 13.89 times the observed variance, if a 95% level of confidence is required.

EXHIBIT 4-2

CONFIDENCE LEVELS FOR THE ASSESSMENT OF MEASUREMENT VARIABILITY

Number of QC Samples (duplicate pairs)	Interval for 95% Confidence that Measurement Error is Within Limits
2	$.27s^2 \le \sigma^2 \le 39.21s^2$
3	$.32s^2 \le \sigma^2 \le 13.89s^2$
4	$.36s^2 \le \sigma^2 \le 8.26s^2$
5	$.39s^2 \le \sigma^2 \le 6.02s^2$
6	$.42s^2 \le \sigma^2 \le 4.84s^2$
7	$.44s^2 \le \sigma^2 \le 4.14s^2$
8	$.46s^2 \le \sigma^2 \le 3.67s^2$
9	$.47s^2 \le \sigma^2 \le 3.33s^2$
10	$.49s^2 \le \sigma^2 \le 3.08s^2$
15	$.54s^2 \le \sigma^2 \le 2.40s^2$
20	$.58s^2 \le \sigma^2 \le 2.08s^2$
25	$.62s^2 \le \sigma^2 \le 1.91s^2$
50	$.70s^2 \le \sigma^2 \le 1.61s^2$
100	$.77s^2 \le \sigma^2 \le 1.35s^2$

s^2 = Observed variance (precision of an estimate).

σ^2 = True variance (population variance).

Note: Assumes data are or have been transformed to normal distribution.
Source: EPA 1990b.

The resources assigned to the collection and analysis of duplicates depend on the concentration of concern and the magnitude of variability for the compound of potential concern.

- If the level of concentration of concern is near the method detection limit, little room for measurement error exists and the precision of the estimate of measurement error is critical.
- If the natural variability of the chemicals of potential concern is relatively large, the major planning effort will be to collect more samples from the exposure pathways, rather than collecting more quality control samples. Guidance on the number of duplicates and blanks is provided in Step IV B. More detailed discussions of the use of quality control measures and selection of the appropriate number of quality control samples may be found in "A Rationale for the Assessment of Errors in the Sampling of Soils" (EPA 1990b).

Step IIIE - Plan for 100% completeness for critical samples.

Planning efforts should be focused on maximizing the collection of useable data from critical samples.

Certain samples in a sampling plan may be designated by the RPM or risk assessor as critical in determining the potential risk for an exposure pathway. For example, if only one background sample is taken for a given medium and exposure pathway, then that sample would be considered "critical." In these cases, completeness of all data associated with the sample is an important performance measure.

The only acceptable level of completeness for critical samples is 100%.

STEP IIIF - Other performance measures.

Other performance measures may be designated to facilitate the monitoring and assessment of sample design implementation. For example, field spikes and field evaluation or audit samples can be used to assess the accuracy and comparability of results. Field matrix spikes are routine samples spiked with the contaminant of interest in the field and do not increase the number of field samples. Field evaluation samples are of known concentration, introduced in the field at the earliest stage possible and subject to the same manipulation as routine samples. Field evaluation samples will increase the total number of samples collected. Performance measures for field spikes and evaluation samples are expressed in terms of percent recovery.

Difficulties associated with field spiking, especially in soil, have resulted in limited use of this practice (EPA 1989c).

Step IV - Determine number of samples.

If the natural variability of the chemicals of potential concern is large, the major planning effort should be to collect more environmental samples.

Exhibit 4-3 details elements of four factors to consider in determining the total number of samples required:

- Exposure pathways.
- Statistical performance objectives (based on site environmental samples).

EXHIBIT 4-3

FACTORS IN DETERMINING TOTAL NUMBER OF SAMPLES COLLECTED

NUMBER OF EXPOSURE PATHWAYS THAT WILL BE SAMPLED

- Media within exposure pathway
- Strata within exposure pathway medium

NUMBER OF SAMPLES FOR EACH EXPOSURE PATHWAY GROUPING GIVEN REQUIRED STATISTICAL PERFORMANCE

- Confidence (1- α) Type I Error
- Power (1- β) Type II Error
- Minimum detectable relative difference

NUMBER OF QUALITY CONTROL SAMPLES

- Field duplicate (collocated)
- Field duplicate (split)
- Blank (trip, field, and equipment (rinsate))
- Field evaluation

NUMBER OF BACKGROUND SAMPLES

- Number of site samples collected
- Minimum detectable relative difference

EXHIBIT 4-4

RELATIONSHIPS BETWEEN MEASURES OF STATISTICAL PERFORMANCE AND NUMBER OF SAMPLES REQUIRED

Coefficient of Variation (%)	Power (%)	Confidence Level (%)	Samples Required to Meet Minimum Detectable Relative Difference		
			5%	10%	20%
10	95	90	36	10	3
15	95	90	78	21	6
20	95	90	138	36	10
25	95	90	216	55	15
30	95	90	310	78	21
35	95	90	421	106	28

Note: Number of samples required in a one-sided one-sample t-test to achieve a minimum detectable relative difference at confidence level and power. C.V. based on geometric mean for transformed data.

Source: EPA 1989c.

- Quality assurance objectives (based on quality control samples).
- Background samples (based on minimum detectable relative difference).

Enter the numbers of samples for each stratum.

Step IVA - Determine number of environmental samples.

The number of environmental site samples is ultimately controlled by statistical performance requirements, given the statistical sample design. The relationship between number of samples and measures of statistical performance depends upon the variability of the chemicals of potential concern, expressed as the coefficient of variation. The relationship between the coefficient of variation for a chemical of potential concern and measures of statistical performance is the basis for determining the number of samples.

The number of samples can be calculated given a coefficient of variation, a required confidence level or certainty, a required statistical power, and a minimum detectable relative difference. Exhibit 4-4 illustrates the relationships between the number of samples required given typical values for the coefficient of variation and statistical performance objectives. Calculation formulas in Appendix IV facilitate the examination of effects beyond the examples cited.

Step IVB - Determine number of quality control samples.

NUMBER OF DUPLICATES

Guidance for determining the number of required duplicate samples is usually one duplicate for every 20 environmental samples. However, this procedure should be modified based on site conditions. For example, the number of duplicates and other quality control samples may be set high for the beginning of site sampling, evaluated after several duplicates to determine routine measurement error, and subsequently adjusted according to observed performance. The information in Exhibit 4-2 associated with Step IIID shows that confidence in measurement error increases sharply when four or more pairs of duplicate samples are taken per medium. Critical samples are recommended for designation as duplicates in the quality assurance sample design.

NUMBER OF BLANKS

Blanks provide an estimate of bias due to contamination introduced by sampling transportation, preservation, or storage.

At least one field blank per medium should be collected each day, and at least one blank must be collected for each sampling process.

Examine results from duplicate and blank samples as early as possible in the sampling operation to ascertain if presumed sampling characteristics are accurate and discover areas where the sampling strategy requires modification.

TOTAL NUMBER OF SAMPLES FOR STRATUM

Add the environmental and quality control samples for each stratum and record these totals on the worksheet. Do not double count duplicate samples in the total.

CONTAMINATION CONCERNS

Indicate on the worksheet if there are any concerns regarding blank contamination and describe the concerns. For example, the number of blank samples may need to be increased if volatile compounds are suspected in a medium.

Step IVC - Determine number of background samples

A sufficient number of background samples must be taken to determine the validity of the assertion that there is no difference between the site and the background at the desired level of confidence. Early sampling and analysis of background samples will indicate the ease with which background levels can be discriminated, and allow modifications to be made to the SAP if necessary.

A minimum of one background sample per medium and exposure area should be taken. As with quality control samples, results from the background sample should be assessed early to see if background levels will severely impact the sampling design. In those instances where background levels are close to on-site contamination levels, it may be necessary to collect as many background samples as site samples. Small numbers of background samples increase the probability of a Type II, false negative error (i.e., that no difference exists between site and background, when a difference does in fact exist). However, rigorous statistical analyses involving background samples may be unnecessary if site and non-site related contamination clearly differ.

Background samples should be collected and analyzed prior to the final determination of the sampling design since the number of samples is significantly reduced if little background contamination is present.

Background levels of contaminants vary by medium and the type of contamination. If a detectable background level of a contaminant occurs infrequently, the number of background samples analyzed might be kept small. Metals often have high rates of detection in background samples. Some pesticides, such as DDT, are anthropogenic and also have high rates of detection in particular matrices. Anthropogenic background levels are also found in sites near industries and urban areas.

Background sampling must be increased in the following situations:

- Contamination exists in more than one medium.
- Expected coefficients of variation in chemicals of concern are high and confirmed by actual data.
- Relative differences between site and background levels are small.
- Site concentrations and concentrations of concern are low.

Step IVD - Calculate total number of samples for medium/pathway.

Obtain the total number of samples required for the exposure pathway in the medium of concern by adding the numbers of environmental, quality control, and background samples recorded on the worksheet. (Duplicate samples should not be double-counted in the total). Record the total number of samples for each stratum (if stratified) on the Sample Design Selection Worksheet.

Step V - Modify sample design as appropriate.

A stratified random sample design is proposed for initial assessment of planning strategy. Now, given the total number of samples required, reconsider the utility of this design on the basis of three factors: hot spot identification, comparability with previous sampling events, and resource issues.

Random or systematic sampling is the best strategy for identifying hot spots.

Step VA - Describe known hot spots and indicate probability of missing a hot spot.

A critical issue for the RPM and risk assessor is whether hot spots exist in the exposure area and the probable size of the hot spot. This information can frequently be deduced from historical data. Hot spots are primarily an issue in soil sampling. Procedures for determining the probability of missing a hot spot are not as effective in random designs as in systematic and geostatistical designs. However, a search strategy which stratifies the area based on grids and then randomly samples within each grid can be used within the classical framework. Systematic and geostatistical design approaches provide the best approach to hot spot identification as described in Step I.

Appendix IV describes numerical procedures and assumptions to determine the probability that a given systematic design will detect a hot spot and provides a calculation formula based on a geometrical argument. To employ this formula, the distance between grid points and the estimated size of the hot spot as a radius must be specified.

Indicate on the Sample Design Selection Worksheet if a hot spot is known to exist in the exposure pathway. If yes, describe each hot spot, including an estimated radius. Based on the calculations in this step, record the probability of missing a hot spot.

Step VB - Establish historical data comparability

The ability to combine data from different sampling episodes or different sampling procedures is a very important consideration in selecting a sampling design. The RPM may wish to assess historical data along with current results or may anticipate that the current data will need to be compared with results from future sampling activities. Consult a statistician in either of these cases to determine if the current sampling design will allow the production of data of known comparability.

Indicate if historical data exist and whether or not they are comparable to current planned data on the Sample Design Selection Worksheet.

Step VC - Identify and address resource issues.

Resource limitations are a major reason for sample design modification. The number of samples required to achieve desired performance measures may exceed resource availability. Modifying the sample design and the efficiency of statistical estimators can reduce sample size, thereby reducing costs and improving overall timeliness for the risk assessment. Alternatively, analytical methods such as field analyses can also reduce cost. Systematic and geostatistical designs can often achieve the required performance measures with fewer samples (Gilbert 1987). Interim sampling can be used to verify initial assumptions of the SAP, increase knowledge of contaminant distribution, and support SAP modifications to reduce the number of samples. On the Sample Design Selection Worksheet, indicate whether resource issues are a concern. If so, explain the issues and record potential design modifications.

4.1.2 BALANCING ISSUES FOR DECISION-MAKING

Completing a number of Sample Design Selection Worksheets (Exhibit 4-1) for different exposure areas, media, and sample design alternatives will enable the RPM and risk assessor to compare and evaluate sample design options and consequences and select the appropriate sample design for each medium and exposure pathway. Practical tradeoffs between response time, analytical costs, number of samples, sampling costs, and level of uncertainty can then be weighed. For example, perhaps more samples can be collected if less expensive analyses are used. Or, if the risk assessment is based on a point source, collection of additional samples to estimate chemical concentrations and distribution can be avoided.

Computer programs are useful tools in developing and evaluating sampling strategies, especially in trading off costs against uncertainty, and identifying situations when additional samples will not significantly affect the useability of the data (i.e., the point of diminishing returns). Each automated system has specific data requirements and is based on specific site assumptions. The major systems which support environmental sampling decisions are listed, contacts for information given, and brief descriptions provided in Exhibit 4-5.

EXHIBIT 4-5

AUTOMATED SYSTEMS[1] TO SUPPORT ENVIRONMENTAL SAMPLING

SYSTEM	EPA CONTACT	DESCRIPTION
Data Quality Objective (Training) - Expert System	Dean Neptune USEPA Quality Assurance Management Staff (202) 475-9464	Training system designed to assist in planning of environmental investigations based on data quality objective process.
ESES Environmental Sampling (Plan Design) - Expert System	Jeff Van Ee Exposure Assessment Div. USEPA, EMSL-LV (702) 798-2367	Expert system designed to assist in planning sample collection. Includes models that address statistical design, QC, sampling procedures, sample handling, budget, and documentation. Current system addresses metal contaminants in a soil matrix. (Expanded application under development, contact EMSL-LV.)
GEO - EAS Geostatistical Environmental Assessment Software	Evan Englund Exposure Assessment Div. USEPA, EMSL-LV (702) 798-2248	Collection of software tools for two-dimensional geostatistical analysis of spatially distributed data points. Programs include file management, contour mapping, kriging, and variogramanalysis.
SCOUT Multivariate Statistical Analysis Package	Jeff Van Ee Exposure Assessment Div. USEPA, EMSL-LV (702) 798-2367	A collection of statistical programs that accept GEO-EAS files for multivariate analysis.
ASSESS Assessment of Errors in Sampling of Soils	Jeff Van Ee Exposure Assessment Div. USEPA, EMSL-LV (702) 798-2367	System designed to assist in assessment of error in sampling of soils. Estimates measurement error variance components. Presents scatter plots of quality control data and error plots to assist in determining the appropriate amount of quality control samples.

[1] All systems will run on any IBM compatible PC AT with 640K RAM (minimum). A fixed disk is recommended.

4.1.3 DOCUMENTING SAMPLE DESIGN DECISIONS

It is important to document the primary issues considered in balancing tradeoffs to accommodate resource concerns, and their impact on data useability. Fully document all final sample design decisions, including the rationale for each decision. During the course of the RI, continue to document pertinent issues that arise and any sampling plan modifications which are implemented.

EXHIBIT 4-6

METHOD SELECTION WORKSHEET

I. Analytes		II. Medium	III. Critical Parameters				IV. Routine Available Methods[3]
A. Chemical or Class of Chemicals of Potential Concern	B. Reporting Requirement[1] (Y or N)		A. Turnaround Time	B. ID Only or ID Plus Quant (ID or ID+Q)	C. Concentration of Concern	D. Required Method Quantitation Limit[2]	

[1] Y= Total reported for compound class.
N = Each analyte reported separately.
[2] Method detection limit should be no greater than 20% of concentration of concern.
[3] Refer to Appendix III for specific methods. Recommend consultation with chemist and/or automated methods search to determine all methods available. (Exhibit 4-7 lists computer systems that support method selection.)

4.2 Strategy for selecting analytical methods

This section describes how to use the Method Selection Worksheet shown in Exhibit 4-6 as a data collection and decision-making tool to identify analytical methods that meet the needs of the risk assessment and to select the most appropriate method for each analyte. The RPM and risk assessor should use this worksheet, or use it as a model to create a worksheet specifically suited to their needs, in order to aid in method selection. Methods selected in this process may be routine or non-routine.

The risk assessor should ensure that critical requirements and priorities are specified on the "Method Selection Worksheet" so that the best available methods can be selected.

Routine methods should be used wherever possible since method development is time consuming and may result in problems with laboratory implementation.

- Routine methods are issued by an organization with appropriate responsibility (e.g., State or Federal agency with regulatory responsibility, professional organization), are validated, documented, and published, and contain information on minimum performance characteristics such as detection limit, precision and accuracy, and useful range.
- Non-routine methods address situations with unusual or problematic matrices, low detection limits or new parameters, procedures or techniques; they often contain adjustments to routine methods.

4.2.1 COMPLETING THE METHOD SELECTION WORKSHEET

Step I - Identify analytes.

List the chemicals of potential concern to the risk assessment for the site on the Method Selection Worksheet. Use the same list of chemicals that appears on the Sample Design Selection Worksheets for the site. Indicate whether each analyte should be reported separately or the total for the compound class reported.

Step II - Identify medium for analysis.

Specify the analysis medium, e.g., soil, sediment, groundwater, surface water, air, biota.

Step III - Decide on critical parameters.

Specify the required data turnaround time (IIIA) as a number of hours or days from the time of sample collection. Indicate whether chemical identification alone is desired or identification plus quantitation (IIIB). Specify the concentration of concern (IIIC) and required method quantitation limit (IIID).

Step IV - Identify available routine methods

Use the final worksheet column to list the methods available that satisfy the requirements in the preceding steps. Reference sources and software are available to assist in identifying routine analytical methods applicable for environmental samples. Routine methods for organics and inorganics analyses are listed in Appendix III. The methods are from the following sources:

- EPA CLP-RAS (EPA 1988g, 1988h).
- EPA SW-846 (EPA 1986a).
- Standard Methods for the Examination of Water and Wastwater, (Clesceri et al. Eds. 1989).
- EPA Series 200, 300, 500, 600 and 1600 Methods (EPA 1983, 1984, 1988j and 1989h).

Other sources of methods are:

- Field Analytical Screening Procedures (FASP) (EPA 1989g).
- Compendium of Field Methods (EPA 1987d).
- Association of Official Analytical Chemists (AOAC).
- American Society for Testing and Materials (ASTM).

Several computer-assisted search and artificial intelligence-based tools are available, including the List of Lists, the SMART methods index, and a computerized reference book on analytical methods. Some of these systems are designed as teaching tools, as well as informational compendia. All offer the ability to rapidly search and compare lists of chemicals and method characteristics from accepted reference sources. Exhibit 4-7 lists software products that aid method selection, identifies contacts for information, and gives a short description of the product.

EXHIBIT 4-7

AUTOMATED SYSTEMS[1] TO SUPPORT METHOD SELECTION

SYSTEM	CONTACT	DESCRIPTION
List of Lists	W. A. Telliard USEPA Office of Water (202) 382-7120	An automated sorting and selection software package that currently contains 150 methods and 1,700 analytes. These are cross-referenced to facilitate selection based on required needs (e.g., analyte detection limit, instrument).
Smart Method Index	John Nocerino Quality Assurance Div. USEPA, EMSL-LV (202) 798-2110	Natural language expert system prototype that provides interactive queries of databases cross-referenced by method, analyte, and performance features.
Geophysical Techniques Expert System	Aldo Maggella Advanced Monitoring Div. USEPA, EMSL-LV (202) 798-2254	An expert system that suggests and ranks geophysical techniques, including soil gas, for applicability of use based on site-specific characteristics.
EPA Sampling and Analysis Data Base	Lewis Publishers 1-800-272-7737	A three-volume set of diskettes and a printed manual provides a search of sampling and analytical method summaries from a menu-driven program of 150 EPA-approved methods. The database can he searched by method, analyte, matrix, and various quality assurance considerations.

[1] All systems will run on any IBM compatible PC AT with 640K RAM (minimum). A fixed disk is recommended.

4.2.2 EVALUATING THE APPROPRIATENESS OF ROUTINE METHODS

Analyte specific methods that provide better quantitation can be used once chemicals of potential concern have been identified by a broad spectrum analysis.

Choice of the proper method is critical to the acquisition of useable data. Routine methods provide data of known quality when used for the analysis of chemicals and sample types described in the method. Data quality issues (precision, accuracy, interferences) are usually described in the method. Examine available methods with respect to the criteria defined on the Method Selection Worksheet. It may be helpful to divide the analyte list into suitable categories based on the types of analysis. For example, a requirement for chromium, cadmium, and arsenic data could not be generated by the same analysis as data for chlorinated hydrocarbons. It may be possible to use several methods independently and combine the data sets for risk assessment purposes. This is done routinely by the CLP, where inorganics (elemental analysis), volatiles, extractable organics, and pesticides are analyzed by different methods. In some cases, no routine method or series of methods will be able to satisfy all criteria and compromises must be considered. The risk assessor, with the advice of an analytical chemist, must then determine which criteria are of highest priority and which can be modified. For example, if a low detection limit is of high priority, turnaround time and cost of analysis will likely increase. If an initial broad spectrum analysis to quickly determine the largest number of chemicals present at the site is of high priority, low detection limit and precision requirements may need to be modified.

TURNAROUND TIME

Turnaround time is determined by the available instrumentation, sample capacity, and methods requirements. Turnaround times for field analyses can be as short as a few hours, while those for fixed laboratory analyses include transport time, and range from several days to several weeks. Field instruments, can provide the quickest results, especially if the data do not go through a formal review process. However, the confidence in chemical identification, and particularly quantitation, may not be as high. In general, methods with quick turnaround times are often less precise and have higher detection limits. If data are needed quickly, a field method can be used for initial results and a fixed laboratory method used to produce more detailed results (or confirm the earlier results), thereby increasing the confidence in field analyses.

SAMPLE QUANTITATION LIMITS

Risk assessment often requires a sample quantitation limit at or below the detection limit for routine methods for many chemicals of toxicological concern. The sample quantitation limits vary according to sample medium. The quantitation limits for chemicals in water samples are often far lower than for the same chemicals in soils, because of co-extractable components in the soil, as well as limitations in sample weight or volume. Pay particular attention to interferences reported by the method, because these will hinder acquisition of acceptable quality data. Interference effects are more pronounced near the method detection limit. Compare documented method interferences with site conditions to identify potential method problems. Some common sources of interference in organic and inorganic analyses are summarized in Exhibits 4-8a and 4-8b. If needed sample quantitation cannot be met by available methods, consult with an analytical chemist for the feasibility of detection at the desired level in the required sample type. The chemist can help determine if method adaptation can resolve the problem or if a non-routine method of analysis can be used.

USEFUL RANGE

The useful range of a method specifies the concentrations of chemicals for which precise and accurate results can be generated. This range is analyte-specific. The lower end of the useful range is the method detection limit, often generically referred to as the "detection limit." If a lower detection limit is required, use of a larger sample or smaller final extract volume can sometimes compensate. However, any interfering chemicals are also concentrated, thereby producing greater interference effects. Above the useful range, the response may not be linear and may affect quantitation. This causes inaccurate and/or imprecise measurements. Reducing the sample size for analysis or diluting the extracted material will bring the concentration within the useful range. With environmental samples, some chemicals are frequently present at the low end of the useful range of the method, while others are above the useful range. In this situation, two analyses are necessary to produce accurate and precise data on all chemicals. The laboratory should be instructed to notify the RPM or responsible contract manager if this occurs in sufficient time for re-analysis within the specified holding time. Both analyses should be reported to

EXHIBIT 4-8a

COMMON LABORATORY CONTAMINANTS AND INTERFERENCES BY ORGANIC ANALYTE

Contamination or Interference	Fraction	Matrix	Effects on Analysis	Removal /[1] Action
Fat/Oil	Extractable organics, pesticides, and PCBs	Tissue, waste, soils	Increased detection limit, decreased precision/ accuracy	GPC (all groups), florisil (pesticides), acid digestion (PCBs only)
Sulfur	Extractable organics, chlorinated and phosphorus-containing pesticides	Sediment, waste, soils	Presence/ absence, detection limits, precision/ accuracy	GPC, copper, mercury, tetrabutyl ammonium sulfate
Phthalate Esters	Chlorinated pesticides, PCBs, and extractable organics	All	False positive identification (pesticides and extractable organics) or positive bias (pesticides and extractable organics)	Florisil, GC-MS confirmation of identity (pesticides, PCBs), evaluation of reagents and method blanks for contamination
Laboratory Solvents	Volatile organics (methylene chloride, acetone, and 2-butanone)	All	False positive identification or positive bias	Confidence in data use based on interpretation of blank data

[1] Source: EPA 1986a.

maximize the useability of both detected and non-detected analytes.

All results should be reported for samples anlayzed at more than one dilution.

PRECISION AND ACCURACY

Routine methods often specify precision and accuracy with respect to specific analytes (chemicals) and matrices (sample media). However, be aware that environmental samples are often difficult to analyze because of the complexity of the matrix or the presence of a large number of contaminants; this usually results in lower levels of precision and accuracy than those cited in the method.

EXHIBIT 4-8b

COMMON LABORATORY CONTAMINANTS AND INTERFERENCES BY INORGANIC ANALYTE

ANALYTE	TECHNIQUE	INTERFERENCE	REMOVAL/ ACTION
ARSENIC	GFAA	Iron, Aluminum	Background correction (not deuterium) (Zeeman).
	ICP	Aluminum	If above 100 ppm, correction factor utilized.
BERYLLIUM	ICP	Titanium, Vanadium	If above 100 ppm, correction factor utilized.
CADMIUM	GFAA	None except possible sample matrix effects	Background correction for matrix effects.
	ICP	Iron	If above 100 ppm, correction factor utilized.
CHROMIUM	GFAA	Calcium	Add calcium, standardize suppression, background correction.
	ICP	Iron, Manganese	If above 100 ppm, correction factor utilized.
LEAD	GFAA	Sulfate	Lanthanum nitrate addition as matrix modifier, background correction.
	ICP	Aluminum	If above 100 ppm, correction factor utilized.
MERCURY	CVAA	Sulfide, High Chloride	Remove interferences with cadmium carbonate (removes sulfide), potassium permanganate (removes chloride), excess hydroxylamine sulfate (removes free chlorine).
SELENIUM	GFAA	Iron, Aluminum	Alternate wavelength for analysis, background correction (not deuterium) (Zeeman).
	ICP	Aluminum	Above 100 ppm, correction factor utilized.
CYANIDE	Colorimetric/ spectrophotometric	Acids, Sulfide, Chlorine oxidizing agents	Increase pH to > 12 in field to remove acids, cadmium carbonate (removes sulfide), ascorbic acid (removes free chlorine).

Key:
ICP - Inductively coupled plasma.
GFAA - Graphite furnace atomic absorption.
CVAA - Cold vapor atomic absorption.

BALANCING ISSUES FOR DECISION-MAKING

The goal of balancing issues in the selection of analytical methods is to obtain the best analytical performance without sacrificing risk assessment requirements. The selection of analytical methods often involves tradeoffs among required detection limit, number of analytes involved, precision and accuracy, turnaround time, and cost. Some choices may conflict with others. By remaining aware of the effect of individual issues on the data quality, the RPM can determine the optimum choices. Several compromises among options are discussed in this section. Features of analytical options available for organic and inorganic analytes are summarized in Exhibits 4-9a through 4-9d.

Cost should be considered only after the most appropriate methods have been determined. Methods requiring specialized instrumentation, such as high resolution mass spectrometry, will be more expensive. Methods for use on complicated matrices such as soil, can be more expensive than similar methods for a simpler matrix such as water. Less expensive methods often have higher detection limits and less specific confirmation of identification. However, the turnaround times are often quicker and a larger number of samples can be analyzed, which significantly increases sampling precision and reduces the probability of missing hot spots. Less expensive methods are often chosen if the site has already been characterized by broad-spectrum analyses. In evaluating routine methods, consider whether analysis of more samples through use of less expensive methods can provide a similar level of data quality to that achieved through the use of more expensive methods on fewer samples.

Field analysis can be used to decrease cost and turnaround time providing data from a broad spectrum analysis are available.

In addition to turnaround time for analysis, time must also be scheduled for data review. This will not hinder the availability of laboratory and

EXHIBIT 4-9a

COMPARISON OF ANALYTICAL OPTIONS FOR ORGANIC ANALYTES IN WATER

Method	MDL	Qualitative Confidence	Timeliness	Precision & Accuracy	Comparability	Cost[1]
CLP RAS						
VOA	n	s	w	n	s	n
BNA	n	s	w	n	s	n
Pesticides	n	n	w	n	s	n
Dioxin	n	s	w	s	s	n
600 SERIES						
GC	s	(w)n	n	n	s	n
VOA	s	s	n	n	s	n
BNA	s	s	n	n	s	n
500 SERIES						
GC	s	(w)n	n	n	s	n
VOA	s	s	n	n	s	n
BNA	s	s	n	n	s	n
SW 846						
GC	s	(w)n	n	n	s	n
VOA	n	s	n	n	s	n
BNA	n	s	n	n	s	n
FIELD SCREEN/FIELD ANALYSIS (Assumes preparation step)						
GC(PCB)	s	s	s	n	s	n
GC(Pesticides)	s	w	s	n	s	n
GC(VOA)	s	w	s	n	s	n
GC(Soil Gas)	s	w	s	n	w	n
GC(BNA)	s	w	s	n	s	s
PHOTO VAC Detector	n	w	s	n	w	n
CLP LOW CONC						
GC	s	(w)n	n	s	s	n
VOA	s	s	n	s	s	n
BNA	s	s	n	s	s	n
1600 SERIES						
GC	s	(w)n	n	s	s	w
VOA	n	s	n	s	s	w
BNA	n	s	n	s	s	w
Dioxin	n	s	n	s	s	w

Key:
s = Method strength.
w = Method weakness.
n = Neither strength nor weakness.

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[1] Cost per sample does not consider funding source.

EXHIBIT 4-9b

COMPARISON OF ANALYTICAL OPTIONS FOR ORGANIC ANALYTES IN SOIL

Method	MDL	Qualitative Confidence	Timeliness	Precision & Accuracy	Comparability	Cost[1]
CLP RAS						
VOA	n	s	w	n	s	n
BNA	n	s	w	n	s	n
Pesticides	n	n	w	n	s	n
Dioxin	n	s	w	s	s	n
SW846						
GC	s	(w)n	n	n	s	n
VOA	n	s	n	n	s	n
BNA	n	s	n	n	s	n
FIELD SCREEN						
GC(PCB)	s	s	s	n	s	n
GC(Pesticides)	w	w	s	n	s	n
GC(VOA)	s	w	s	n	s	n
GC(Soil Gas)	s	w	s	n	w	n
GC(BNA)	s	w	s	n	s	s
PHOTO VAC Detector	n	w	s	n	w	n
1600 SERIES						
GC	s	w(n)	n	s	s	w
VOA	n	s	n	s	s	w
BNA	n	s	n	s	s	w
Dioxin	n	s	n	s	s	w

Key:
s = Method strength.
w = Method weakness.
n = Neither strength nor weakness.

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[1] Cost per sample does not consider funding source.

EXHIBIT 4-9c
COMPARISON OF ANALYTICAL OPTIONS FOR INORGANIC ANALYTES IN WATER AND SOIL

Method	MDL	Qualitative Confidence	Timeliness	Precision & Accuracy [1]	Comparability [2]	Cost [3]
CLP RAS						
ICP	w(n)	s	w	s	s	n
GFAA	s	s	w	s	s	n
Flame AA	w(n)	n	w	n	n	n
200 Series						
GFAA	s	s	w	s	s	n
AA	w(n)	n	w	n	n	n
ICP-MS[4]	s	s	w	n	s	w
ICP-Hydride[4]	s	w	w	n	n	w
Field Screen						
XRF	w(n)	n	s	w	w	s
AA	w(n)	n	s	n	n	s

Key:
s = Method strength.
w = Method weakness.
n = Neither strength nor weakness.

[1] CLP inorganic water assays are more accurate and precise than soil assays.

[2] ICP and GFAA are comparable at medium to high ppb levels. For As, Pb, Se, Tl and Sb at less than 20 ppb, GFAA is the method of choice.

[3] Cost per sample does not consider funding source.

[4] ICP-MS and ICP-Hydride methods are relatively new; therefore, precision, accuracy, and comparability estimates based on large statistical sampling are not available.

EXHIBIT 4-9d

COMPARISON OF ANALYTICAL OPTIONS FOR ORGANIC AND INORGANIC ANALYTES IN AIR

Method[1]	MDL	Qualitative Confidence	Timeliness	Precision & Accuracy	Comparability	Cost[2]
CLP VOA Cannister	2-5 ppb	s	n	s	n	n
CLP VOA Tenax	2-30 ppb (for most)	s	n	s	n	n
CLP BNA	0.00001-0.001 ug/m3	s	n	s	n	n
CLP Metals	3-10 ng/m3	s	n	s	n	n

Key:
s = Method strength.
w = Method weakness.
n = Neither strength nor weakness.

[1] The methods described are new Statements of Work.

[2] Cost per sample does not include funding source.

field data for preliminary use if a tiered data review sequence is incorporated. Use of a tiered approach to both data generation and review will often provide a good compromise between use of a swift analysis of a broad spectrum of compounds and longer-term accurate quantitative measurement of individual chemicals of potential concern.

When using the tiered approach consider the use of split samples (i.e., sending sample splits for analysis by field and fixed laboratories). Quantitative comparison can then be made between the precision and accuracy of the field analyses and that of the fixed laboratory. Confirmation of identification by both field and fixed laboratories also increases data confidence and useability. Field methods should be used with a 10% rate of confirmation or comparison by CLP or other fixed laboratory analyses.

4.2.3 DEVELOPING ALTERNATIVES WHEN ROUTINE METHODS ARE NOT AVAILABLE

If routine methods are not available to suit the parameters of interest, it is often due to one or more of the following factors:

- The detection limit of commonly available instrumentation has been reached, and a lower detection limit is required for the risk assessment.
- An unusual combination of chemicals are of potential concern.
- The sample matrix is complex.
- The chemicals of potential concern or other analytical parameters are unique to a particular site.

Consult an analytical chemist for specific guidance on the potential limitations of alternative approaches. These may include adaptation of a routine method or use of a non-routine method. Be aware that certain conditions, such as extremely low detection limits for some chemicals, may be beyond the capability of current analytical technology.

ADAPTATION OF ROUTINE METHODS

Adapting routine methods may be a solution when routine methods will not suffice to provide the desired data even after compromises have been made with respect to parameters such as turnaround time and cost. Using the completed method selection worksheet as the starting point, work closely with an analytical chemist to formulate suitable modifications to the routine method. Evaluate and document any effects on data quality that will result from the modifications.

Within the CLP, such analyses can be obtained by Special Analytical Services (SAS) requests. Before analysis of site samples, it may be advisable to confirm the laboratory's ability to perform the adapted method with preliminary data.

USE OF NON-ROUTINE METHODS

If a routine method cannot be adapted to provide the necessary data, then existing non-routine methods that meet the criteria can be used. Such analyses can be found in the research literature, usually catalogued by analyte or instrument. On-line computerized search services can be of considerable help in identifying such methods. Work interactively with an analytical chemist in reviewing selected methods. Recognize that non-routine analyses require a greater level of capability and experience from the analytical laboratory, and that turnaround time can be longer because the method may need alteration during analysis if problems develop.

DEVELOPMENT OF NEW METHODS

Developing new methods should be the option of last resort. The RPM and risk assessor should consider recommending the development of new methods only for chemicals of potential concern that are difficult to analyze and for which analyses will be required for a number of sites over a period of several years.

Although designing a method based on data available for a given instrument and analytes may seem straightforward, the process is time consuming and expensive. Unforeseen problems can arise when the method is implemented in the laboratory, often with environmental matrices such as effluents and soils. Problems can occur even when laboratory personnel have superior training and experience. Consider the following points when requesting the development of a new method:

- Select a laboratory with a recognized reputation for performance and flexibility in a related area. Treat laboratory personnel as partners in the development process. This is true whether a commercial or a government laboratory is used.
- Identify sources for authentic standards of the chemicals in question to support method development. Computer programs such as the EPA List of Lists may be useful for such a determination.
- Be aware that turnaround time for useable data may be long (potentially several months) because of the likelihood of trying different approaches before discovering an acceptable procedure.

4.2.4 SELECTING ANALYTICAL LABORATORIES

In selecting a laboratory to produce analytical data for risk assessment purposes, identify and evaluate the following laboratory qualifications:

- Possession of appropriate instrumentation and trained personnel to perform the required analyses, as defined in the analytical specifications.
- Experience in performing the same or similar analyses.
- Adequate laboratory capacity to perform all analyses in the desired time frame.
- Intra-laboratory quality control review of all generated data, independent of the data generators.
- Adequate laboratory protocols for documentation and sample security.

For non-routine analyses, the laboratory should have highly trained personnel and instrumentation not dedicated to production work, especially if new methods or untested modifications are requested.

Accreditation programs, where established, monitor the level of quality of laboratory performance within the scope of their charters. Many of these programs periodically provide performance evaluation samples that the laboratories must analyze within certain limits in order to maintain their status. Prior to laboratory selection, request that laboratories provide information about their performance in accreditation programs. This information can be used for evaluation of laboratory quality, in the case of similar matrices and analytes. Laboratory adherence to standards of performance such as the Good Laboratory Practices regulations also provides a measure of laboratory quality.

4.2.5 WRITING THE ANALYSIS REQUEST

Include the following items in the analysis request:

- A clear, complete description of the sample preparation, extraction, and analysis procedures including detailed performance specifications. For adaptation of routine methods, specify the routine method and explicitly state alterations with applicable references.
- Documented reporting requirements.
- Laboratory access to required authentic chemical standards.
- Mechanism for the laboratory to obtain EPA technical assistance in implementing method modifications or performing non-routine methods.

In the analysis request for a non-routine method, reference the published material with a detailed specification of procedures and requirements prepared by the analytical chemist who has been working with the RPM and risk assessor. The specification must include the frequency, acceptance criteria, and corrective action requirements for each of the following:

- Standardization, including initial and continuing calibration.
- Method blank performance (permissible level of contamination).
- Spike sample recovery requirements.
- Duplicate analysis requirements.
- Performance evaluation or quality control sample results.

Allow time for the laboratory to review the analysis request and question any part of the description that seems unclear or unworkable according to its experience with the analytes or sample matrix. Preliminary data, such as precision and accuracy data on a subset of the analytes, can be requested to determine if the laboratory can implement the proposed method. Should the criteria not be met in the preliminary analyses, the analytical chemist should advise the laboratory on additional method modifications to produce the required data. In some cases, even qualitative data can be used to note the presence of chemicals of potential concern.

In all cases, require the laboratory performing the analyses to contact the RPM, responsible chemist, or risk assessor at the first sign of a problem that may affect data quality. The EPA technical team can then judge the magnitude of the problem and determine appropriate corrective action.

Chapter 1
Introduction and Background

Chapter 2
The Risk Assessment Process

Chapter 3
Criteria for Evaluating Data Useability in Baseline Risk Assessments

Chapter 4
Steps for Planning for the Acquisition of Useable Environmental Data in Baseline Risk Assessments

Chapter 5
Assessment of Environmental Data for Useability in Baseline Risk Assessments

Chapter 5
Assessment of Environmental Data for Useability in Baseline Risk Assessments

- Describes minimum requirements for useable data.
- Explains how to determine actual performance compared to objectives.
- Recommends corrective actions for critical data not meeting objectives.
- Describes options for combining data from different sources and of varying quality into the risk assessment.

ACRONYMS FOR CHAPTER FIVE

CLP	Contract Laboratory Program
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
DQO	Data Quality Objective
GC	Gas Chromatography
ICP	Inductively Coupled Plasma Atomic Emission Spectroscopy
MS	Mass Spectrometry
QAPjP	Quality Assurance Project Plan
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RPD	Relative Percent Difference
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SQL	Sample Quantitation Limit
UCL	Upper Confidence Limit

5.0 ASSESSMENT OF ENVIRONMENTAL DATA FOR USEABILITY IN BASELINE RISK ASSESSMENTS

This chapter provides specific guidance for the assessment and interpretation of environmental data for use in baseline risk assessments. The discussion of data assessment is organized according to six phases that define the assessment process for each data useability criterion. Exhibit 5-1 lists each of the data useability assessment phases in the order in which a risk assessor would evaluate them, and gives references to the sections where they are discussed in the manual.

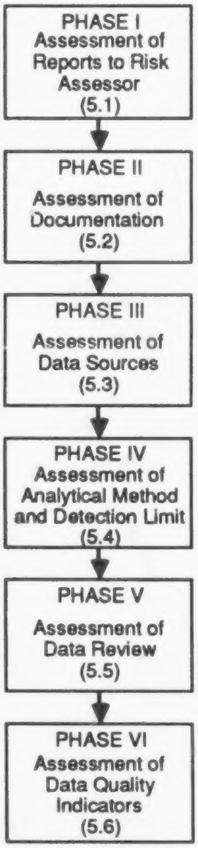
As presented in Chapter 3, the four basic decisions to be made with the data collected in the RI are:

- What contamination is present and at what levels?
- Are site concentrations sufficiently different from background?
- Are all exposure pathways identified and examined?
- Are all exposure pathways fully characterized?

The uncertainty associated with each data useability criterion affects the level of confidence associated with each of these major decisions.

EXHIBIT 5-1

DATA USEABILITY ASSESSMENT PHASES


PHASE I
Assessment of Reports to Risk Assessor
(5.1)
PHASE II
Assessment of Documentation
(5.2)
PHASE III
Assessment of Data Sources
(5.3)
PHASE IV
Assessment of Analytical Method and Detection Limit
(5.4)
PHASE V
Assessment of Data Review
(5.5)
PHASE VI
Assessment of Data Quality Indicators
(5.6)

How to Conduct the Data Assessment

The risk assessor or RPM examines the data, documentation, and reports for each assessment phase (I - VI) to determine if performance is within the limits required by the planning objectives. The data assessment process for each phase should be conducted according to the step-by-step procedures discussed later in this chapter. For each phase, minimum requirements are listed, potential effects of not meeting the minimum requirements are discussed, and corrective action options are presented. Exhibit 5-2 summarizes the major impact on assessment associated with each data useability criterion.

The following activities are performed for each assessment phase being evaluated:

- Identify or determine performance objectives and minimum data requirements.

  Performance objectives should have been specified in planning for all components of the acquisition of environmental data, as discussed in Chapter 4. The first step of each assessment phase is to assemble these performance objectives and note any changes made to them since their initial specification. The performance objectives should also be compared with the minimum acceptable requirements for data useability that are presented in the following sections of this chapter. These minimum requirements can be adopted as the performance objectives for any component if current objectives are inappropriate or were not specified.

- Determine actual performance compared to performance objectives.

  The next step in the assessment of each phase is to examine the analytical results to determine the performance that was actually achieved for each data useability criterion. This performance should then be compared with the objectives established during planning. Take particular note of performance for samples or analyses that are critical to the baseline risk assessment. All deviations from the objectives should be noted. In those cases where actual performance was better than that required in the objective, it is useful to determine if this is due to unanticipated characteristics of the site, or to superior performance in some stage of the data acquisition. Where actual performance does not meet performance objectives for data critical to the risk assessment, the next step is corrective action.

- Determine and execute any corrective action required.

Corrective action should be focused on maximizing the useability of data from critical samples.

Corrective action should be taken to improve data useability when actual performance fails to meet performance objectives for data critical to the risk assessment. Corrective action options are described in Exhibit 5-3. These may involve communication with the RPM and the technical team to resolve the problem or actions on the part of the risk assessor. Sensitivity analysis may be performed by the risk assessor to estimate the effects of not meeting performance requirements on the certainty of the risk assessment. Corrective actions can improve data quality and reduce uncertainty, and may eliminate the need to qualify or reject the data.

EXHIBIT 5-2

MINIMUM REQUIREMENTS, IMPACT, AND CORRECTIVE ACTIONS FOR DATA USEABILITY CRITERIA

DATA USEABILITY CRITERION	MINIMUM REQUIREMENT	IMPACT ON RISK ASSESSMENT	CORRECTIVE ACTION
5.1 Reports To Risk Assessor	• Site description • Sample design with sample locations • Analytical method and detection limit • Results on per-sample basis, qualified for analytical limitations • Sample-specific quantitation limits (SQLs) and detection limit for non-detects • Field conditions for media and environment • Preliminary reports	• Unable to perform quantitative risk assessment	• Request missing information • Perform qualitative risk assessment
5.2 Documentation	• Sample results related to geographic location (chain-of-custody records, SOPs, field and analytical records)	• Unable to assess exposure pathways • Unable to identify appropriate concentration for exposure areas	• Request locations identified • Resampling
5.3 Data Sources	• Analytical data results for one sample per medium per exposure pathway • Broad spectrum analysis for one sample per medium per exposure pathway • Field measurements data for media and environment	• Potential for false negatives and positives • Increased variability in exposure modeling	• Resampling or reanalysis for critical samples
5.4 Analytical Method and Detection Limit	• Routine methods used for critical samples and chemicals of potential concern • Detection limit less than 20% of concentration of concern	• Unquantified precision and accuracy • False negatives	• Reanalysis • Resampling and analysis for critical samples • Documented statements of limitation for non-critical samples
5.5 Data Review	• Correctness of analytical results reviewed	• Potential for false negatives or false positives • Increased variability and bias due to analytical process, calculation or transcription errors	• Perform data review
5.6 Data Quality Indicators	• Sampling variability quantified for each analyte • QC samples required to identify and quantify precision and accuracy • Sampling and analytical precision and accuracy quantified	• Unable to quantify confidence levels for uncertainty • Potential for false negatives or false positives	• Resampling for critical samples • Perform qualitative risk assessment • Perform quantitative risk assessment for non-critical samples with documented discussion of potential limitations

EXHIBIT 5-3

CORRECTIVE ACTION OPTIONS WHEN DATA DO NOT MEET PERFORMANCE OBJECTIVES

- Retrieve missing information.
- Resolve technical or procedural problems by requesting additional explanation or clarification from the technical team.
- Request reanalysis of sample(s) from extract.
- Request construction and re-interpretation of analytical results from the laboratory or project chemist.
- Request additional sample collection and analysis for site or background characterization.
- Model potential impact on risk assessment uncertainty using sensitivity analysis to determine range of effect.
- Adjust or impute data based on approved default options and imputation routines.
- Qualify or reject data for use in risk assessment.

Using a Worksheet to organize the data assessment

The level of certainty associated with the data component of the risk assessment varies according to the amount of data meeting performance objectives. For each performance measure, the risk assessor determines whether the data involved are satisfactory (data accepted), questionable (data qualified) or unsatisfactory (data rejected). A worksheet is provided as a organizational tool to assist in this process.

The Data Useability Worksheet, Exhibit 5-4, is for the risk assessor to use in documenting data assessment decisions. For each data useability criterion, record the decision as accept, accept with qualification, or reject the data for use in the risk assessment. Record the justification or rationale for each decision in the comments section.

The remainder of this chapter explains how to assess data using the data useability criteria. Assessment Phase I identifies the data and documentation required for risk assessment (Section 5.1), Phases II through V involve the assessment of data useability criteria for documentation (Section 5.2), data sources (Section 5.3), analytical methods and detection limits (Section 5.4), and data review (Section 5.5). Phase VI includes the assessment of sampling (Section 5.6.1) and analytical performance (Section 5.6.2) according to each of five data quality indicators: completeness, comparability, representativeness, precision, and accuracy.

5.1 Phase I: Assessment of Reports to Risk Assessor

The data and documentation supplied to the risk assessor must be evaluated for completeness and appropriateness, and to determine if any changes were made to the work plan and the SAP during the course of the work. The SAP discusses the sampling and analytical design and contains the Quality Assurance Project Plan (QAPjP) and a list of data quality objectives, where such indicators were developed. The risk assessor should receive preliminary and final data and reports, as described in the following sections.

5.1.1 PRELIMINARY REPORTS

Preliminary data should be used as a basis for identifying sampling or analysis deficiencies and taking corrective action.

Preliminary analytical data and reports allow the risk assessor to begin assessment once the sampling and analysis effort has begun. These initial reports have three functions:

- The risk assessor can begin to characterize the baseline risk assessment on the basis of actual data. Chemicals of interest will be identified and the concentration variability confirmed.
- Potential problems in either sampling or analysis can be identified and the need for corrective action can be assessed. For example, based on the preliminary data, additional samples may be required or the method may need to be modified because of matrix interferences.
- RI time schedules are more likely to be met if the risk assessment process can begin before the final data reports are produced.

The major advantage to preliminary review of data by the risk assessor is the potential for feedback and corrective action while the RI is still in process to improve the quality of the data for the risk assessment.

5.1.2 FINAL REPORT

Problems in data useability due to sampling can affect all chemicals involved in the risk assessment whereas problems due to analysis may only affect specific chemicals.

EXHIBIT 5-4
DATA USEABILITY WORKSHEET

Data Useability Criteria		Decision [1]	Comments
1.	Reports to Risk Assessor		
2.	Documentation A. WP/SAP/QAPjP		
	B. SOPs		
	C. Field and Analytical Records		
3.	Data Sources A. Analytical		
	B. Non-analytical		
4.	Analytical Methods		
5.	Data Review		

[1] Decision: Accept, Qualified Accept, Reject

EXHIBIT 5-4
DATA USEABILITY WORKSHEET
(continued)

Data Useability Criteria		Decision[1]		Comments
6.	Data Quality Indicators A. Completeness	Sampling		
		Analytical		
		Combined		
	B. Comparability	Sampling		
		Analytical		
		Combined		
	C. Representativeness	Sampling		
		Analytical		
		Combined		
	D. Precision	Sampling		
		Analytical		
		Combined		
	E. Accuracy	Sampling		
		Analytical		
		Combined		

[1] Decision: Accept, Qualified Accept, Reject

The minimum data, documentation, and report materials needed to prepare the risk assessment are:

- A description of the site, including a detailed map showing the location of each sample, the site relative to surrounding structures, terrain features, receptor populations, indications of air and water flow, and a description of the operative industrial process (if any).
- A map with sampling locations.
- A description and rationale of the sample design and sampling procedures.
- A description of the analytical methods used.
- Results for each analyte and each sample, qualified for analytical limitations.

- Sample-specific quantitation limits (SQLs) and detection limits for undetected analytes, with an explanation of the detection limits reported and detection limit qualification for analytical limitations.
- A narrative explanation of the level of data review used and the resulting data qualifiers indicating direction of bias, based on the assessment of the results from quality control samples (i.e., blanks, duplicates, and spikes for field and laboratory).
- A description of field conditions and physical parameter data as appropriate for the media involved in the exposure assessment.

If any of these materials are not available and cannot be obtained, it may not be possible to perform a quantitative baseline risk assessment. The RPM or risk assessor should attempt to retrieve missing deliverables from the source.

Additional reports and data that are useful to the risk assessor, such as data results on CLP diskettes, are listed in Exhibit 3-10. Access to this information will improve the efficiency and quality of the risk assessment, but not having it will not necessarily require the data to be qualified or rejected. Minimum requirements for reports to the risk assessor are listed in Exhibit 5-2.

5.2 Phase II: Assessment of Documentation

Three types of documentation must be assessed: chain-of-custody records, SOPs, and field and analytical records.

Chain-of-custody records for risk assessment must document the sample locations and the date of sampling so that sample results can be related to geographic location and to specific sample containers. If a sample result cannot be related to a sampling date and the point of sample collection, the results are unuseable for the quantitative risk assessment. Full scale chain-of-custody procedures (extending from sample collection through analysis) are not required for risk assessments, although they are required for other purposes, such as enforcement or cost recovery.

SOPs are products of the planning process and serve to describe and specify the procedures to be followed during sampling and analysis. They are quality assurance procedures that increase the probability that a data collection design will be properly implemented. SOPs increase consistency in performing tasks and, as a result, determine the level of systematic error and reduce the random error associated with sampling and analysis. Knowledge that SOPs were developed and followed increases confidence in the data. However, once the data have been collected and analyzed, the existence of SOPs does not increase the data quality. The existence of SOPs for each process or activity involved in data collection is not a minimum requirement, but the value of SOPs if data problems occur is significant.

Field and analytical records are the products of sampling and analysis, and document the procedures followed and the conditions of the procedures. Field and analytical records such as field logs and raw instrument output may be useful to the risk assessor as back-up documentation but they are not minimum requirements. Like SOPs, such records are critical to resolving problems in interpretation, but they may not directly affect the level of certainty of the risk assessment.

Minimum requirements for documentation are listed in Exhibit 5-2.

5.3 Phase III: Assessment of Data Sources

Data source assessment involves the evaluation and use of historical and current analytical data. Historical analytical data should be evaluated according to data quality indicators and not source.

The minimum analytical data requirement for risk assessment is that one sample per medium exposure pathway be analyzed using a broad spectrum analytical technique, such as GC-MS methods for organic analytes, or ICP for inorganic analytes. The impact of not having a broad spectrum analysis from a fixed laboratory source is an increased probability of false negatives because all chemicals of potential concern at the site may not be identified. In the absence of a broad spectrum analysis, the best corrective action is to take additional samples. If additional samples cannot be obtained, the probability of false negatives and positives should be considered high, and the level of certainty of the risk assessment is decreased.

The broad spectrum analysis and any other analytical data are subject to the basic documentation and data review requirements discussed in this chapter. The location of the sample data point must be known, as well as the method and sample quantitation limit achieved for analytical results.

Guidance for the assessment of analytical data to determine false positives and false negatives and the precision and accuracy of concentration results is provided in Section 5.6.2.

Field measurements of physical characteristics of the site, medium, or contamination source are a critical data source, whose omission can significantly affect the ability of the risk assessor to perform a quantitative assessment. Physical site information is required to perform exposure fate and transport modeling. Examples of such data are particle size, pH, clay content, and porosity of soils, wind direction and speed, topography, and percent vegetation. RAGS Exhibit 4-2, Examples of Modeling Parameters for Which Information may need to be Obtained During a Site Sampling Investigation, provides a list of data elements according to medium modeling category. If not collected during sampling, these parameters cannot be determined. The use of default options and routines to estimate missing values allows the use of the model but increases the uncertainty associated with the exposure assessments.

Minimum requirements for data sources are listed in Exhibit 5-2.

5.4 Phase IV: Assessment of Analytical Method and Detection Limit

The risk assessor compares method detection limits with analyte-specific concentrations of concern to determine their appropriateness. The assessment of preliminary data and reports will provide an opportunity to review the detection limits early and resolve any problems. If the compound is reported as not detected, then the detection limits reported must be lower than the corresponding concentration of concern. The minimum requirement is that the method detection limit be no more than twenty percent of the concentration of concern, so that the sample-specific quantitation limit will also be below the concentration of concern. Data for chemicals identified above the proper ratio of detection limit to concentration of concern can be used with good confidence. Information concerning non-detects or detections at or near detection limits should be qualified according to the degree of acceptable uncertainty, as described in Section 5.6.2.

For example, the concentration of concern for arsenic in groundwater could be 70 ug/L for an average daily consumption of 2 L of water by a 70 kg adult. The detection limit of a suitable method for examination of groundwater samples from such a site should be no greater than 14 ug/L.

Minimum requirements for analytical methods and detection limits are listed in Exhibit 5-2.

5.5 Phase V: Assessment of Data Review

Data review assesses the quality of analytical results and is performed by a professional with a knowledge of the analytical procedures. The requirement for risk assessment is that only data that have been reviewed according to a specified level or plan will be used in the quantitative risk assessment. Any analytical errors or limitations in data that are identified by the review must be explicitly noted in the risk assessment if the data are used. An explanation for qualifiers used must be included with the review report.

All data should receive some level of review whenever possible. The risk assessor may receive data prior to the quantitative baseline risk assessment that were not reviewed. Data that have not been reviewed must be explicitly identified because the lack of review increases the uncertainty for the risk assessment. These data may contain a variety of false positives, false negatives, and quantitation errors. Unreviewed data may also contain transcription errors and calculation errors. Data may be used in the preliminary assessment before review, but must be reviewed before use in the final risk assessment.

Depending upon data user requirements, the level and depth of the data review is variable. The level and depth of the data review may be determined during the planning process. The data review process must include an examination of laboratory and methods performance for the samples and analytes involved. This examination includes:

- Evaluation of data completeness.
- Verification of instrument calibration.
- Measurement of laboratory precision using duplicates; measurement of laboratory accuracy using spikes.
- Examination of blanks for contamination.
- Assessment of adherence to method specifications and quality control limits.
- Evaluation of method performance in the sample matrix.

Specific data review procedures are dependent upon method and data user requirements. Sections 5.6.1 and 5.6.2 detail procedures for evaluating quality control samples for laboratory and method performance. CLP data review procedures are performed according to criteria outlined in "Laboratory Data Validation: Functional Guidelines for Evaluating Organic (or Inorganic) Analyses" (EPA 1988d, 1988e).

Minimum requirements for data review are listed in Exhibit 5-2.

5.6 Phase VI: Assessment of Data Quality Indicators

The assessment of data quality indicators as presented in this chapter is significant to determine data useability. The assessment is split into two parts that separately address the assessment of data quality indicators from sampling (Section 5.6.1) and analysis (Section 5.6.2).

Qualified data can usually be used for quantitative risk assessments.

The assessment of data quality indicators for either sampling or analysis involves the evaluation of five indicators: completeness, comparability, representativeness, precision, and accuracy. The effects of uncertainty in completeness, comparability and representativeness influence the certainty of chemical identification by increasing the probability of false negatives and positives. Variation in completeness, comparability, representativeness, precision and accuracy and affects the uncertainty of estimates of average concentration and reasonable maximum exposure. Once the indicator is examined or a numerical value is determined, the results can be compared to the performance objectives established during RI planning. This comparison determines the useability of the data and any required corrective actions.

A summary of the minimum requirements for data quality indicators is presented in Exhibit 5-2, and the evaluation process is illustrated in Exhibit 5-5. Specific requirements for each indicator are presented in the sampling and analytical data quality indicator assessment sections below.

5.6.1. ASSESSMENT OF SAMPLING DATA QUALITY INDICATORS

The major activity in determining the useability of data based on sampling is assessing the effectiveness of the sampling operations performed. Samples provided for analysis must answers to the four basic decisions to be made with RI data in the risk assessment cited at the beginning of this chapter.

Completeness

Minimum requirements:

- 100% for critical samples. Background samples and broad spectrum analyses are usually critical.
- Sufficient number of samples to meet specified performance measures.

Impact:

- A reduction in the number of samples reduces site coverage and may affect representativeness.
- Ability to differentiate site levels from background.
- False negatives.
- Reduction in confidence levels and power.
- Upper confidence limit estimates may be inflated.

Corrective action:

- Resampling.
- Additional analysis of samples already at laboratory.

Completeness is calculated by the following formula:

$$\text{Percent Completeness} = \frac{\text{(Number of accepted data points)} \times 100}{\text{Total number of samples collected}}$$

This measure of completeness is useful for data collection and analysis management but misses the key risk assessment issue, which is the total number of data points available and accepted for each chemical of potential concern. All occurrences of incompleteness should be assessed to determine if an acceptable level of data useability can still be obtained or whether the level of completeness must be increased, either by further sampling or by other corrective action. Any decrease in the number of samples from that specified in the sample design will affect the final results. In this case, the option of obtaining more samples should be reviewed.

Typical causes for sample attrition include: site conditions preventing sample collection (e.g., a well runs dry), sample breakage, and invalid or unusable analytical results. Completeness can affect the uncertainty involved in risk assessments by reducing the available number of samples on which identification of chemicals at the site and estimates of concentration levels are based. The reduction in the number of samples from the original design further affects representativeness by reducing site coverage and increases the variability in concentration estimates. Only the collection of additional samples will resolve the problem, unless the samples involved were duplicates or splits. In this case, or if the cause was laboratory performance, the extracts may be considered for reanalysis.

Comparability

Minimum requirement:

- Unbiased sample design or documented reasons for selecting another sample design.

Impact:

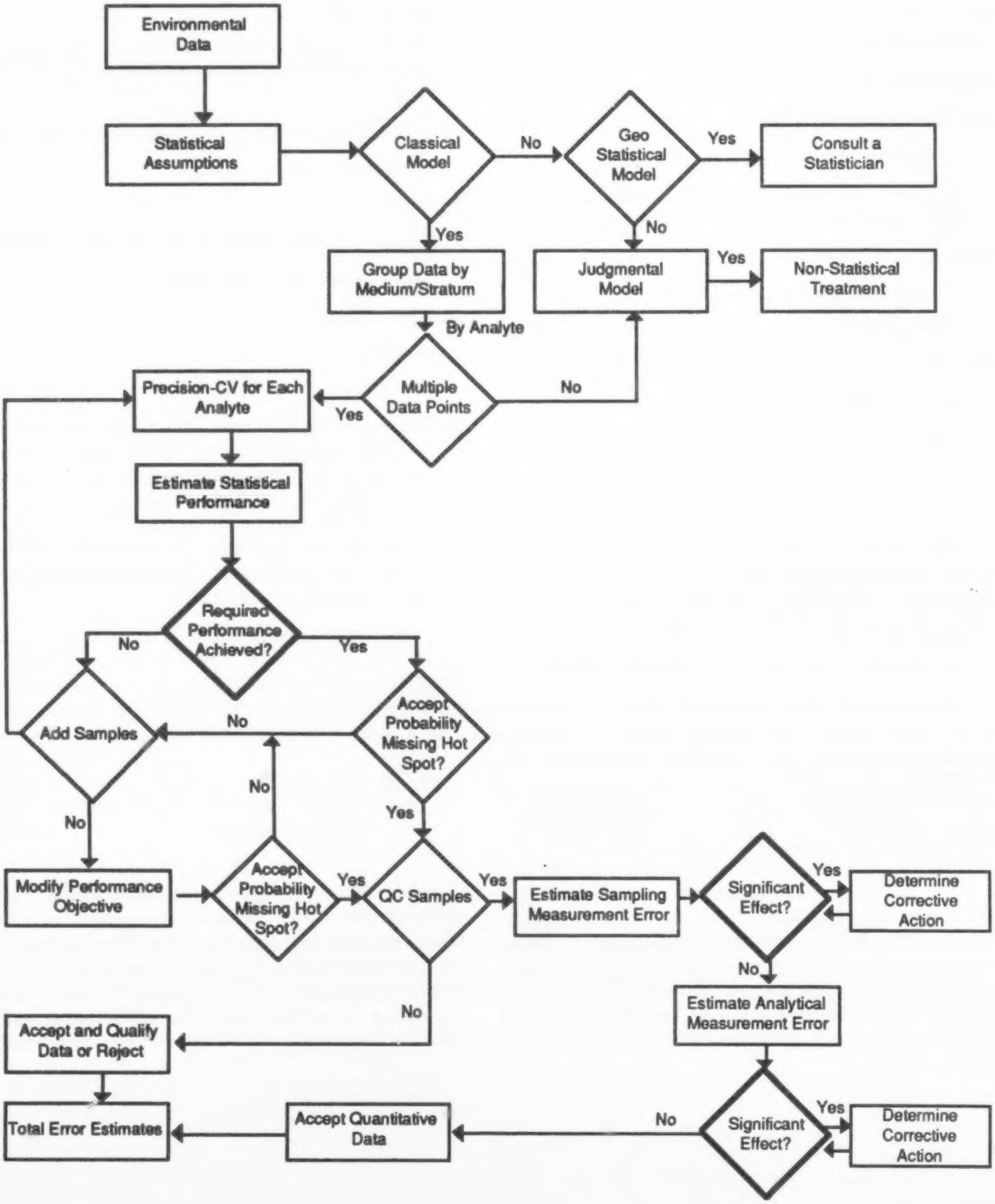
- Non-additivity of sample results.
- Reduced confidence, power, and ability to detect differences, given the number of samples available.

Corrective action:

- Statistical analysis of effects of bias.

Comparability issues have little impact on performance measures associated with sampling provided that the sample design is unbiased, and the sample design or analytical methods have

EXHIBIT 5-5
USING DATA QUALITY INDICATORS TO DETERMINE DATA USEABILITY


Environmental Data
Statistical Assumptions
Classical Model
No
Geo Statistical Model
Yes
Consult a Statistician
Yes
No
Group Data by Medium/Stratum
Judgmental Model
Yes
Non-Statistical Treatment
By Analyte
Precision-CV for Each Analyte
Yes
Multiple Data Points
No
Estimate Statistical Performance
Required Performance Achieved?
No
Yes
Add Samples
No
Accept Probability Missing Hot Spot?
No
Yes
No
Modify Performance Objective
Accept Probability Missing Hot Spot?
Yes
QC Samples
Yes
Estimate Sampling Measurement Error
Significant Effect?
Yes
Determine Corrective Action
No
Estimate Analytical Measurement Error
No
Accept and Qualify Data or Reject
Total Error Estimates
Accept Quantitative Data
No
Significant Effect?
Yes
Determine Corrective Action

not changed over time. If any of these factors change, the risk assessor may experience difficulties in combining data sets to estimate the reasonable maximum exposure. The determination of RME is based on the principal of estimating risk over time for the exposure area. The ideal situation occurs when samples can be added within the basic design and the only effect is to decrease the level of uncertainty.

Representativeness

Minimum requirements:

- Sample data representative of exposure area.
- Sample preparation procedures (i.e., filtering, compositing, and sample preservation) do not affect representativeness.

Impact:

- Bias high or low in estimate of RME.
- False negatives.

Corrective action:

- Additional sampling.
- Examination of effects of sample preparation procedures.

Representativeness of data is critical to risk assessments. The results of the risk assessment will be biased to the degree that the data do not reflect the chemicals and concentrations present in the exposure area of interest. Non-representative chemical identification will result in false negatives. Non-representative estimates of concentration levels may be high or low. Only additional sampling will resolve the problems associated with unrepresentative sampling, unless the risk assessment is accepted with explicit discussion of its potential limitations.

It is important to determine whether any changes have occurred in the actual sample collection that convert an originally unbiased sampling plan into a biased sampling episode. Bias in unbiased designs is difficult to assess because no measure of the true value is known. Bias in non-statistical designs is assumed.

Representativeness is primarily a planning concern. The solution is in the design of a sampling plan that is representative. Once the design is implemented, only the sampling variability is evaluated during the assessment process, unless contamination occurs in the quality control samples or blanks. Completeness problems decrease representativeness and increase the potential for false negatives and the bias in estimations of concentration, but only the increase in variability can be estimated.

Precision

Minimum requirements:

- Confidence level of 80%.
- Power of 90%.
- Minimum detectable relative differences specified in SAP and modified after analysis of background samples if necessary.
- One set of duplicates or more, as specified in the SAP.
- Measurement error specified.

Impact:

- Errors in decisions to act or not act based on analytical data.
- Unacceptable level of uncertainty.

Corrective action:

- Add samples.
- Adjust performance objectives.

The two basic activities performed in the assessment of precision are estimating sampling variability from the observed spatial variation and estimating the measurement error attributable to the data collection process. Assumptions concerning the sample design and data distributions must be examined prior to interpreting the results. This examination will provide the basis for selecting calculation formulas and knowing when statistical consultation is required.

The type of sample design selected is critical to the estimation of sampling variability as discussed in Sections 3.2 and 4.1. If the sample design is purposive, the nature of the sampling error cannot be determined and estimates of the average concentrations of analytes may not be representative of the site.

The distribution of the data must always be determined before applying statistical measures.

The nature of the observed chemical data distribution affects estimation procedures. The estimation of variability and confidence intervals will become complex if the distribution cannot be assumed normal or to approximate normal when transformed using standard procedures such as the transformation to log normal. Estimates of the 95% upper confidence limit (UCL) of the average concentration for the RME should be based on an analysis of the frequency distribution of the data whenever the database is sufficient to support such analysis. The use of statistical tests comparing the distribution of the observed data with the normal or some other distribution is preferred. Graphs of data without statistical test results may also be acceptable for some data sets. Statistical computer software can assist in the analyses of data distribution.

If the analysis shows that the data are not normally distributed, the risk assessor should transform the data to a normal distribution, if possible, to facilitate statistical analyses. After data are normalized, the UCL of the arithmetic mean can be calculated for data that are logarithmically distributed (RAGS Section 6.4.1). If log normal is not appropriate, other parametric models such as pareto, gamma, or beta, might be used or non-parametric approaches utilized. A statistician should be consulted, since the wrong choice of the distributional model can result in low power and even invalid tests.

Sampling Variability

Exhibit 5-6 summarizes the assessment procedures for the evaluation of variability from different sampling procedures. The estimation of confidence levels, power, and minimum detectable relative differences requires assumptions about the coefficients of variation from sampling variability for each chemical of potential concern. The RPM or risk assessor should discuss the implications of these assumptions with a statistician to determine their potential impacts on data useability.

> *The statistical measures of performance most applicable to site conditions should be determined before assessing data useability.*

Once the statistical assumptions and observed analyte variability are known, selected statistical performance measures can be assessed to determine the data quality achieved. Additional samples may be needed or modified data quality objectives required as a result of evaluating sampling variability. Three issues are involved in the assessment of required statistical performance:

- Level of certainty or confidence
- Power
- Minimum detectable difference

The required level for each of the three critical statistical performance measures should be included in the SAP as data quality objectives (DQOs). The user's data quality requirements defined by these statistical measures determine the number of samples that are taken during data collection. Recommended minimum statistical performance parameters for data useability in risk assessment are provided in Exhibit 5–7.

EXHIBIT 5-6

STEPS TO ASSESS SAMPLING PERFORMANCE

1. Confirm statistical assumptions.
2. Summarize analyte detection data by strata: media within site or site subgroups and strata within media.
3. Transform analyte concentration data so distribution is approximately normal.
4. Calculate the coefficient of variation for each analyte detected.
5. Using Exhibit 4-4 "Relationships Between Measures of Statistical Performance and Number of Samples Required," look up the range of power, confidence level and minimal detectable differences for the calculated coefficient of variation.
6. Compare the statistical performance measures required to those achievable given the coefficient of variation and sample size.
7. If the performance objectives are achieved, go to step 9.

   If the required statistical performance levels are not met, then additional samples must be taken or one or more of the performance parameters must be changed.

   If samples are to be added, Exhibit 4-4 and the calculation formulas in Appendix IV can be used to determine the number needed.
8. If the performance parameters are to be changed, the parameter to be changed should be the one which will increase the probability of taking unnecessary action as opposed to unnecessary risk.
9. Examine the results of the quality control samples. If none exist, the sample results must be considered to be qualitative.
10. If the quality control sample results indicate possible bias through contamination, take appropriate corrective action.

To determine whether the performance objectives have been met, first summarize the sample results at the analyte level by stratum, including media within a site or site subgroups, and stratum within media. If a particular combination of stratum and analyte yields only a single data point, the issue of sampling error is not considered relevant, and the assessment proceeds to the assessment of analytical error for that stratum and analyte combination. Situations involving a single data point should be treated as instances of risk assessment based on an average concentration.

EXHIBIT 5-7

RECOMMENDED MINIMUM STATISTICAL PERFORMANCE PARAMETERS FOR RISK ASSESSMENT

NULL HYPOTHESIS: ON-SITE CONTAMINANT CONCENTRATIONS ARE NOT HIGHER THAN THE BACKGROUND

- Confidence level (Type I error): 80% minimum, reject null when true (take unnecessary action).
- Power (Type II error): 90% minimum, accept null when false (fail to take action when risk).
- Minimum detectable difference: 10% - 20% usually depends on concentration of concern.

Source: EPA 1989c.

In the majority of cases, for stratum/analyte combinations with multiple data points, the distribution should be examined for normality and transformed to log normal. The coefficient of variation is calculated for each stratum/analyte combination. If the distribution resulting from the transformation is not normal, a new distributional model will need to be identified and validated in consultation with a statistician. Non-parametric procedures which require no distributional assumptions may also be used.

Once the coefficient of variation is calculated, the number of samples required to achieve any specific statistical performance measure can be determined from tables or statistical formulas. Conversely, the statistical performance achieved, given the coefficient of variation, can also be determined. The statistical performance achieved should be compared to the requirements stated in planning. If the performance objectives are achieved, the risk assessor can proceed to the assessment of measurement error.

For example, if the required statistical performance objectives are not met, additional samples must be taken or one (or more) of the performance parameters must be changed. If samples are added, the tables or formulas can be used to calculate the number of samples required. If a performance parameter is changed, the one to be changed should be the one which will increase the probability of taking unnecessary action as opposed to unnecessary risk. As a result, the confidence level would be reduced first, the minimum detectable relative differences would be increased second, and the level of power would be reduced last. Minimum recommended levels of reduction for use in risk assessment are 80% confidence levels, 90% power, and 10-20% minimum detectable relative differences. Exhibit 5-7 summarizes the recommended data quality objectives for statistical performance parameters.

Measurement Error

Measurement error is estimated using the results of duplicate samples. The estimate represents the difference between the reported values. This type of variation has four basic sources: sample collection procedures, sample handling and storage procedures, analytical procedures, and data processing procedures. The use of duplicate samples to determine measurement error is discussed in section 5.5 under data review procedures.

Variability due to sampling can be estimated from field duplicates, or collocated samples if the sample is also analyzed as the laboratory duplicate. Otherwise, the field duplicates determine total within-batch measurement error including analytical error.

The formula for computing the relative percent difference (RPD) between duplicates is:

$$\text{RPD} = \frac{|R1 - R2|}{(R1 + R2)/2} \times 100$$

where R1 and R2 are the results from the first and second duplicate samples, respectively.

Accuracy

Minimum requirements:

- Spikes to assess accuracy of non-detects and positive sample results if specified in the SAP.
- Blanks to determine contamination.

Impact:

- False negatives.
- False positives.

Corrective action:

- Consider re-sampling at affected locations.

Accuracy is controlled primarily by the analytical process and is reported as bias. The bias of the sample design cannot be determined since the true value of the chemicals of concern in the exposure area can never be known. However, certain sample designs describe in Chapter 4 produced unbiased results if followed.

The bias associated with the measurement process can be estimated using field spikes on field evaluation or audit samples to assess the accuracy and comparability of results. These estimates will reflect the effects of sample collection, handling, holding times, and the analytical process on the value of the sample collected.

Bias is estimated for the measurement process by computing the percent recovery for the spiked or reference compound as follows:

$$\text{Percent Recovery} = \frac{(\text{Measure amount - Amount in Unspiked sample}) \times 100}{\text{Amount Spiked}}$$

Because of the inherent problems associated with the spiking procedure and the interpretation of recovery, spikes are considered minimum requirements only if specified in the SAP.

Field matrix spikes are currently not recommended for use in soils (EPA 1989c).

Field blanks are evaluated to estimate the potential bias caused by contamination from sample collection, preparation, shipping and/or storage. Results for the analysis of field blanks indicate whether contamination resulted in bias but are not estimates of accuracy. Bias is computed as follows:

$$\text{Percent Bias} = \frac{\text{(Measured amount)} \times 100}{\text{Required Detection Limit}}$$

Blanks are of primary concern for the analysis of bias involved in sampling because of the difficulty in performing field spikes and the availability of appropriate reference standards and matrix for evaluation samples.

5.6.2 ASSESSMENT OF ANALYTICAL DATA QUALITY INDICATORS

Determining the useability of analytical results for the risk assessor begins with the review of quality control samples and qualifiers. The review is used to determine an overall assessment of analytical performance as determined by laboratory and method performance. Note that it is more important to evaluate the effect on the data than to determine the source of the error. The data package is reviewed as a whole for some criteria. Data are reviewed at the sample level for certain criteria, such as holding time. Factors affecting the accuracy of identification and precision and accuracy of quantitation of individual chemicals, such as calibration and recoveries, must be examined analyte-by-analyte. The qualifiers used in the review of CLP data are presented and the effect on data quality is discussed in this section. Exhibit 5-8 presents a summary of the quality control samples and the data use implication of qualified data. Corrective action options are shown in Exhibit 5-3.

EXHIBIT 5-8

USE OF QUALITY CONTROL DATA FOR RISK ASSESSMENT

QUALITY CONTROL CRITERION	EFFECT ON IDENTIFICATION WHEN CRITERION IS NOT MET	QUANTITATIVE BIAS	USE
Spikes (High Recovery)	-	High	Use data as upper limit.
Spikes (Low Recovery)	False Negative[1]	Low	Use data as lower limit.
Duplicates	None, unless analyte found in one duplicate and not the other. Then either false positive or negative.	High or Low[2]	Use data as estimate - poor precision.
Blanks	False Positive	High	Set confidence level 5x blank. Use data above confidence level. Use data below confidence level as estimate.
Calibration	-	High or Low[2]	Use data as estimate unless problem is extreme.
Tune	False Negative	-	Reject data or examine raw data and use professional judgment.
Internal Standards[3] (Reproducibility)	-	-	Use data as estimate - poor precision.
Internal Standards (High Recovery)	-	Low	Use data as lower limit.
Internal Standards (Low Recovery)	False Negative[1]	High	Use data as upper limit.

1 False negative only likely if recovery is near zero.
2 Effect on bias determined by examination of data for each individual analyte.
3 Includes surrogates and system monitoring compounds.

In environmental analysis, sample media can be more complex than expected as in the case of sludge or oily wastes or can contain interfering chemicals whose presence cannot be predicted in both precision and accuracy measurements. The risk assessor must examine the reported precision and accuracy data to determine useability. Ranges used for rejection and qualification of CLP data have been determined based on the analysis of target compounds in environmental media (soil, and water). These ranges, documented in "Laboratory Data Validation: Functional Guidelines for Evaluating Organics/Inorganics Analyses" can be used in the absence of specifications in the planning documents (EPA 1988d, 1988e).

Completeness

Minimum requirements:

- Percentage of sample completeness determined during planning.
- 100% for critical samples (one sample per medium per exposure pathway).
- All data from critical samples considered crucial.

Impact:

- Consequences generally decrease as the number of samples increases.
- Data for critical samples have significantly more impact than incomplete data for non-critical samples.
- For critical samples, decrease useability of data.
- For non-critical samples, potential decrease in useability of data.

Corrective action:

- Determine whether the missing data are crucial to the risk assessment (i.e., data from critical samples).
- Resampling or sample re-analysis to fill data gaps.

The completeness for analytical data required for risk assessment is defined as the number of chemical-specific data results for an exposure area that are determined acceptable after data review, expressed as a percent of the total:

$$\text{Percent Completeness} = \frac{\text{(acceptable samples)} \times 100}{\text{total samples}}$$

An analysis is considered complete if all data generated are determined to be acceptable measurements as defined in the SAP. Data for each analyte should be present for each sample. In addition, data from quality control samples necessary to determine precision and accuracy should be present. Quality control samples and the effects of problems associated with these samples are discussed in section 5.6.2.

Comparability

Minimum requirements:

- The analytical methods used must have common analytical parameters.
- Same units of measure used in reporting.
- Similar detection limits.
- Equivalent sample preparation techniques.

Impact:

- Increase in overall error.

Corrective action:

- Preferentially use those data that provide the most definitive identification and quantitation of the chemicals of potential concern. For organic chemical identification, GC-MS data are preferred over GC data generated with other detectors. For quantitation, examine the precision and accuracy data along with the reported detection limits.
- Sample re-analysis using comparable methods.

The need to combine data from different sampling events and/or different analytical methods should be anticipated.

Comparability is a very important qualitative data indicator for analytical assessment, and is a critical parameter when considering the combination of data sets from different analyses for the same chemicals of potential concern. The assessment determines if analytical results being reported are equivalent to data obtained from similar analyses. Only comparable data sets can readily be combined for the purpose of generating a single risk assessment calculation.

The use of routine methods simplifies the determination of comparability because all laboratories use the same standardized procedures and reporting parameters. In other cases, the risk assessor may have to consult with an analytical chemist to evaluate whether different methods are sufficiently comparable to combine data sets. The risk assessor should request complete descriptions of non-routine methods. A preliminary assessment can be made by comparing the analytes, useful range, and detection limit of the methods. If different units of measure have been reported, all measurements must be converted to a common set of units before comparison.

Representativeness

Minimum requirements:

- As specified in the SAP.

Impact:

- Inaccurate identification or estimate of concentration that leads to inaccurate calculation of risk.
- If a large portion of the data are rejected or if all data from analyses of samples at a specific location are rejected, the remaining data may no longer sufficiently represent the site.

Corrective action:

- For critical samples, re-analyses of samples or resampling of the affected site areas. For non-critical samples, re-analyses or re-sampling should be decided by the RPM in consultation with the technical team.
- If the re-sampling or re-analyses cannot be performed, document in the site assessment report what areas of the site are not represented due to poor quality of analytical data.

Representativeness is determined by examining the sampling plan, as discussed in Section 3.2. In determining the representativeness of the data, the evaluator examines the degree to which the data meet the performance standards of the method and to which the analysis represents the sample submitted to the laboratory. Analytical data quality affects representativeness since data of low quality may be rejected for use in risk assessments. Holding time, sample preservation, and results from analyses of blanks all affect the representativeness of analytical data.

Precision

Minimum requirements:

- Duplicates and splits requirements as specified in the SAP.

Impact:

- Increased variability of quantitative results.
- False negatives or false positives for measurements near the detection limit.

Corrective action:

- Analysis of new duplicate samples.
- Review laboratory protocols to ensure comparability.
- Use precision measurement to determine confidence limits for the effects on the data.

- If there is too much variability in the analyses, the risk assessor can use the larger sample result to set an upper bound on the risk.

Precision is a measure of the repeatability of a single measurement and is evaluated from the results of duplicate samples and splits. The relative percent difference (RPD) between duplicates is calculated using the following formula:

$$\text{RPD} = \frac{|R1 - R2|}{(R1 + R2)/2} \times 100$$

Low precision can be caused by poor instrument performance, inconsistent application of method protocols, or by a difficult, heterogeneous sample matrix. The last effect can be distinguished from the others because it is unique to a single sample or set of samples from the same location.

If split samples have been analyzed by different methods or different laboratories, then data users have a measure of the quality of individual techniques. Splits are particularly effective in cases when one laboratory is a reference laboratory. If both sets of data exhibit the same problems, then laboratory performance can usually be ruled out as a source of error. Splits are also useful when using non-routine methods or comparing results from different analytical methods.

Accuracy

Minimum requirements:

- Use of methods (routine methods whenever possible) that specify expected or required recovery ranges using spike or other quality control measures.
- As specified in the SAP.
- No chemicals of potential concern detected in the blanks.

Impact:

- Potential for false negatives. If spike recovery is low, it is probable that the method or analysis is biased low for that analyte and values in all related samples may underestimate the actual concentration.
- Potential for false positives. If spike recovery exceeds 100%, interferences may be present, and it is probable that the method or analysis is biased high. Analytical results overestimate the actual concentration of the spiked analyte.

Corrective action:

- In many validated methods the percent recovery is used as a correction factor in calculating the analyte concentration. However, no correction factor is applied for CLP data.
- If recoveries are extremely low or extremely high, the risk assessor should consult with an analytical chemist to identify a more appropriate method for re-analysis of the samples.

Accuracy is a measure of overestimation or underestimation of reported concentrations and is evaluated from the results of spiked samples. Recoveries from spiked or performance evaluation samples can be calculated using the following formula:

$$\text{Percent Recovery} = \frac{(\text{measured amount - amount in unspiked sample}) \times 100}{\text{amount spiked}}$$

The procedures will vary according to differences in the number of measurements and the precision of the estimates. Data that are not reported by confidence limits cannot be assigned weights based on precision and should not be combined for use (Taylor 1987).

Spiked samples are particularly useful in the analysis of complex sample types because they help the reviewer determine the extent of bias on the sample measurement. A set of standards at known concentrations is mixed into a portion of the sample or into distilled water prior to sample preparation and analysis. The analytical results are compared to the amount spiked to determine the level of recovery. It is important to note that unless every sample is spiked, spike recoveries present only a trend rather than a specific quantitative measure.

Results from blanks can be used to estimate the extent of high bias in the event of contamination. The following procedures should be implemented to prevent the assignment of false positive values due to blank contamination:

- If the field blanks are contaminated and the laboratory blanks are not, the risk assessor can conclude that contamination occurred prior to receipt of the samples by the laboratory. If the contamination is significant (i.e., it will interfere with the determination of risk), consider resampling at affected locations.
- If it is not possible to resample, the risk assessor must assess the effect of the contamination on the potential for false positives. Often, this determination can be made by examining data from samples located nearby. If all samples and blanks show the same level of a particular chemical, the presence of the chemical in the samples is most likely due to contamination.
- If the laboratory blanks are contaminated, the laboratory should be required to rerun the associated analyses. This is especially important in the case of critical analytes or samples. Before reanalyses, the laboratory must demonstrate freedom from contamination by providing results of a clean laboratory blank. Note: if laboratory blanks are contaminated, field blanks will generally also be contaminated.
- If reanalysis is not possible, then the sample data must be qualified. "Laboratory Data Validation: Functional Guidelines for Evaluation of Organics/Inorganics Analyses"

provides examples of blank qualification (EPA 1988d, 1988e). Chemicals detected in the associated samples below the action level defined in the Functional Guidelines are considered undetected.

Data qualifiers

All of the data generated by the Routine Analytical Services (RAS) of the CLP are reviewed and qualified by regional representatives according to the guidelines found in "Laboratory Data Validation: Functional Guidelines for Evaluation of Organics/Inorganics Analyses" (EPA 1988d, 1988e) as modified to fit the requirements of the individual regions.

Data qualified "U" or "J" are useable for risk assessment purposes.

Analytes qualified with a U are considered not detected. If data precision and accuracy are good (as determined by the quality control samples), data are entered in the data summary tables in the data validation report as the SQL or corrected quantitation limit (method detection limit corrected for sample factors such as dilution and percent moisture), and qualified with a U. Note that the same chemical can be reported undetected in a series of samples at different concentrations because of sample differences. The use of zero, half the detection limit, or the corrected method detection limit as reported in the data summary tables will determine minimum, average, or maximum risk, respectively.

Data qualified with an R are rejected because performance requirements in the sample or in associated quality control analyses were not met. For example, if a mass spectrometer tune is not within specifications, neither the identification nor quantitation of chemicals can be accepted with confidence. Extremely low recoveries of a chemical in a spiked sample might also warrant an R designation for that chemical in associated samples because of the risk of false negatives (see Appendix VI).

Data qualified with a J present a more complex issue. J qualified data are considered estimated because quantitation in the sample or in associated quality control samples did not meet specifications. The justification for qualifying the data is explained in the validation report and is proposed to be included on a qualifier summary table submitted with the validation report by draft revisions of the functional guidelines. Data can be biased high or low for qualification as estimated. The bias can often be determined by examining the results of the quality control samples used to qualify the data. For example, if interfering levels of aluminum are found in inorganic analysis of the interference check sample (ICS), the sample results are probably biased high because the iron signal overlap is added to the signal being reported. When volatile organic compounds are qualified J for holding time violation, the results are usually biased low because some of the volatile compounds may have evaporated during storage.

Data associated with contaminated blanks are not considered estimated and are not flagged J. The presence of the blank contaminant chemical in the analytical samples is questionable at levels up to five to ten times those found in the blank, depending on the nature of the analyte. An action level is determined for each chemical based on the quantity found in the blank, and data above the action level is accepted without qualification. Data between the Contract Required Quantitation (Detection) Limit (CRQL, CRDL) and the action level are qualified U (undetected) because the confidence in the detection is low due to blank contamination.

Estimated organics and inorganics data that are below the CRQL or CRDL are qualified as UJ. This qualifier signifies that the chemical is not detected but the precision of the measurement is not good enough for confidence in the quantitation limit. UJ is used for the same reasons as J but the appropriate quantitation limit is reported rather than the amount found.

Other qualifiers may be added to the analytical data by the laboratory. A set of qualifiers (or flags) has been defined by the CLP for use by the laboratories to denote problems with the analytical data. These qualifiers and their potential use in risk assessment are discussed in RAGs (EPA 1989a).

5.6.3 COMBINING THE ASSESSMENT OF SAMPLING AND ANALYSIS

Once the quality of the sampling and analysis effort has been assessed using the five data quality indicators, the problem becomes one of combining the results to determine the overall assessment of a particular indicator across sampling and analysis. Combining the assessment for completeness, comparability, and representativeness is discussed in this section as a qualitative procedure. Statistical models are available for combining data sets with different variability and bias. The risk assessor should consult a chemist or statistician if the magnitude of the sampling and analysis effort warrants the use of a formal statistical treatment of comparability.

The basic model for estimating total variability across sampling and analysis components is presented in Exhibit 5-9. A non-statistical approach to combining the assessment results is suggested in Exhibit 5-10. Using this approach, each data quality indicator is assessed to determine whether a problem exists in either sampling or analysis. This assessment leads to different combinations of problem determination. For example, completeness may have been a problem in sampling [yes] but not a problem in analysis [no]; the combination is [yes/no].

EXHIBIT 5-9

BASIC MODEL FOR ESTIMATING TOTAL VARIABILITY ACROSS SAMPLING AND ANALYSIS COMPONENTS

$$\sigma_t^2 = \sigma_m^2 + \sigma_p^2$$

where σ_t = total variability
σ_m = measurement variability
σ_p = population variability

$$\sigma_m^2 = \sigma_s^2 + \sigma_h^2 + \sigma_{ss}^2 + \sigma_a^2 + \sigma_b^2$$

where σ_s = sampling variability (standard deviation)
σ_h = handling, transportation and storage variability
σ_{ss} = preparation variability (subsampling variability)
σ_a = laboratory analytical variability
σ_b = between batch variability

NOTE: It is assumed that the data are normally distributed or that a normalizing data transformation has been performed.

Source: EPA 1990b.

EXHIBIT 5-10

COMBINING DATA QUALITY INDICATORS FROM SAMPLING AND ANALYSIS INTO A SINGLE ASSESSMENT OF UNCERTAINTY

Data Quality Indicators	Assessment of Problems		Combined Sampling and Analytical Determination[1]
	Sampling	Analytical	
Completeness	YES NO	YES NO	YES/YES YES/NO NO/YES
Comparability	YES NO	YES NO	YES/YES YES/NO NO/YES
Representativeness	YES NO	YES NO	YES/YES YES/NO NO/YES
Precision	YES NO	YES NO	YES/YES YES/NO NO/YES
Accuracy	YES NO	YES NO	YES/YES YES/NO NO/YES

[1] The combination NO/NO indicates that the data quality indicator will not affect the level of uncertainty in data useability.

Once assessment patterns based on the determination of a problem have been established, some basic guidance is given on the combinations. This guidance is qualitative in nature and is presented only to assist in organizing the data assessment problem for the application of professional judgment. If the assessment pattern is [no/no], the issue of combining results is not a problem. Conversely, if the pattern is [yes/yes], the issue of combining results is an issue of the effects of the combined magnitudes. Instances of combined sampling and analysis problems for a single indicator will have significant effects on the risk assessment uncertainty. The most complicated assessment pattern to interpret is encountered when a problem occurs in one area but not in another (e.g., in sampling but not in analysis). This situation is briefly discussed for each indicator in the following sections.

Completeness

An incomplete sample can be considered incomplete for all analytes, while analytical incompleteness is usually related to particular analytes. In the instance of a completeness problem [yes/yes], the effect on the risk assessment will vary according to chemical. For some chemicals, the data points will be lost in both sampling and analysis.

The effects of a loss in the number of sample points for a particular chemical could be as much as 50%. For example, if collection of 10 samples was planned and one sample could not be collected because of site access problems, one was broken in transport, and the laboratory experienced analysis problems with three samples for the chemical of potential concern causing the data to be rejected, then only five data points remain.

If the assessment pattern is [yes/no], the effects are distributed across all chemicals involved in the risk assessment. If the pattern is [no/yes] the effects are localized to the particular chemical affected.

Comparability

Comparability problems in sampling are primarily due to different sample designs and time periods. Seasonal variations are treated like spatial variations since the risk assessment is calculated as risk over time. Data can be averaged and considered as a single data set. For analytical data, comparability problems are related primarily to the use of different methods and laboratories. A pattern of [yes/yes] will indicate that the risk assessor will have considerable difficulty in combining the various data sets into a single assessment of risk. In situations of [yes/no] and [no/yes], the problem of sampling comparability is more difficult to resolve. Models exist for determining comparability between methods and integrating results across laboratories. These models involve the general statistical approach to confirming data sets with different but known variability and bias (Taylor 1987).

Representativeness

Representativeness is critical to the risk assessment in the sampling area. Non-representativeness affects both false negatives (chemicals not identified) and estimates of concentration magnitudes and, therefore, affects estimates of reasonable maximum exposure (RME). Analytical representativeness involves the question of whether the analysis results represent the sample collected. For example, holding times and sample preservation can cause the analytical results not to be representative of the sample collected. These questions should be treated separately in the discussion of effects.

Precision

Sampling variability typically overshadows variability introduced by the measurement process, which includes analytical variability. If precision is a problem in both sampling and analysis, the risk assessor should focus on the impact of sampling variability on the estimate of RME and the resulting confidence limits. Unless the sampling variability is low and the analytical variability very high, the effects of analytical variability will be minimal in comparison to the effects of sampling variability.

Accuracy

The assessment of accuracy with regard to sampling is focused primarily on recoveries from spiked or performance evaluation samples. Blank contamination can indicate the likelihood of false positives. For analysis, both blank contamination and analytical performance are reflected by spike recoveries. If the pattern is [yes/yes] for accuracy, this may require identifying blank contaminants and integrating the identification of contamination across field and laboratory blanks.

If the accuracy pattern is [no/yes], then the issue is the analytical performance. Low variability in sampling as measured by low coefficients of variation for chemicals of potential concern should increase the risk assessor's concern over an analytical accuracy problem. High sampling variability (CV>25) will greatly reduce the real effects of analytical bias on the level of certainty of the risk assessment.

Chapter 1
Introduction and Background

Chapter 2
The Risk Assessment Process

Chapter 3
Criteria for Evaluating Data Useability in Baseline Risk Assessments

Chapter 4
Steps for Planning for the Acquisition of Useable Environmental Data in Baseline Risk Assessments

Chapter 5
Assessment of Environmental Data for Useability in Baseline Risk Assessments

Chapter 6
Application of Data to Risk Assessments

Chapter 6
Application of Data to Risk Assessments

- Provides procedures to determine the uncertainty of the analytical data.
- Explains how to distinguish site from background levels of contamination and determine presence (absence) of contamination.
- Discusses how to characterize exposure pathways.

ACRONYMS FOR CHAPTER SIX

RAGS	Risk Assessment Guidance for Superfund
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure

6.0 APPLICATION OF DATA TO RISK ASSESSMENT

This chapter provides guidance for integrating the assessment of data useability to determine the overall level of confidence of the completed risk assessment. This guidance builds on each of the previous chapters in this manual.

- Chapter 2 explained the risk assessment process and the roles and responsibilities of key participants. Exhibit 2-3 defined a continuum of level of certainty in the baseline risk assessment result based on the ability of the risk assessor to quantify or qualify the level of confidence associated with the analytical data.
- Chapter 3 defined six data useability criteria and examined preliminary issues that must be considered during sampling and analysis planning to increase the certainty of the analytical data collected for the risk assessment.
- Chapter 4 presented strategies for planning sampling and analysis activities based on the six data useability criteria.
- Chapter 5 described how to use each data useability criterion in a separate assessment phase to determine the effect of sampling and analysis problems on data quality and on the useability of the data in the baseline risk assessment.

The Data Useability Worksheet (Exhibit 5-4) was designed to assist the risk assessor in summarizing the determination of data quality across the various assessment phases. The worksheet forms the basis for this chapter's discussion of the impact of the quality of the analytical data on the level of confidence of the risk assessment.

6.1 Assessment of Level of Certainty Associated with the Analytical Data

This section explains how to assess the level of confidence in sampling and analytical procedures in the context of the four major decisions to be made by the risk assessor with environmental analytical data. Exhibits in this section apply the data useability criteria, defined in Chapter 3 and appearing on the Data Useability Worksheet, to the four decisions. The data useability criteria affect the level of confidence involved in each decision. Accordingly, the level of certainty in the data collection and evaluation component of the risk assessment will affect the overall certainty of the risk estimate.

6.1.1 WHAT CONTAMINATION IS PRESENT AND AT WHAT LEVELS?

The risk assessor's first task is to use the analytical data to determine what contamination is present at the site and at what levels (i.e., what potential exists for increased risk from this contamination). Exhibit 6-1 lists the criteria from the Data Useability Worksheet that affect this decision. The most critical question to be answered about the analytical data before calculating the risk is the probability of false positives or false negatives in the data. Risk assessors are concerned primarily with false negatives because their occurrence causes the assessment of risk to be biased low. False positives cause the calculated risk to be biased high.

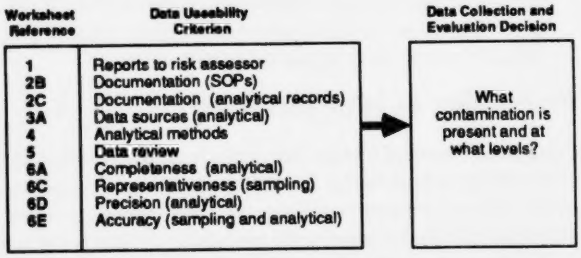
The major concern with false negatives is that the decision based on the risk assessment may not be protective of human health.

Probability of false negatives

False negatives occur when chemicals of potential concern are present but are not detected by the analytical method or the sample design. The following parameters from the Data Useability Worksheet can be used to determine the probability of false negatives: analytical methods, data review, sampling completeness, sampling representativeness, analytical completeness, analytical precision and accuracy, and combined error.

EXHIBIT 6-1

DATA USEABILITY CRITERIA AFFECTING CONTAMINATION PRESENCE



Worksheet Reference	Data Useability Criterion	Data Collection and Evaluation Decision
1	Reports to risk assessor	What contamination is present and at what levels?
2B	Documentation (SOPs)	
2C	Documentation (analytical records)	
3A	Data sources (analytical)	
4	Analytical methods	
5	Data review	
6A	Completeness (analytical)	
6C	Representativeness (sampling)	
6D	Precision (analytical)	
6E	Accuracy (sampling and analytical)	

False negatives can occur if sampling is not representative, if detection limits are above concentrations of concern, or if spike recoveries are very low.

Sampling contributes to the probability of false negatives if too few samples were taken or if sections of the site were not sampled. If sampling of any exposure pathway was not representative, the probability of false negatives increases.

Knowing the analyte-specific detection limits is critical to the determination of the probability of false negatives. Recovery values from spikes, internal standards, surrogates, and system monitoring compounds are used to assess the level of accuracy and precision in the laboratory data and determine whether the detection limits stated in the analytical methods have been met by the laboratory.

- If the concentration of concern is at or below the detection limit for any analyte, the probability of false negatives for that analyte is high. This probability should have been documented during planning if no analytical methods were found with detection limits below the concentration of concern.
- If the spike recoveries are acceptable or biased high as documented during the data review process and the detection limits are below the concentration of concern for each analyte, the probability of false negatives is low.
- If the spike recoveries are biased low and the detection limits are below the concentration of concern for each analyte, the probability of false negatives is directly related to the amount of bias. The effect is more pronounced the closer the concentration of concern is to the detection limits.
- The possibility of false negatives should be carefully evaluated whenever samples have been highly diluted (i.e., diluted beyond normal method specifications).

Probability of false positives

False positives occur when a chemical of concern is not present at the site but is detected by the analytical method. Assessment of the following parameters from the Data Useability Worksheet can be used to determine the probability of false positives: analytical methods, data review, sampling accuracy, analytical completeness, analytical precision and accuracy, and combined error.

False positives can occur when blanks are contaminated or spike recoveries are very high.

Sampling and analysis uncertainties connected with false positives can be assessed by examining the results of quality control samples. Blank contamination is the most important indicator for determining the probability of false positives, particularly when accompanied by high spike recoveries. As described in Chapter 5, samples can be contaminated during sampling, storage, or analysis, resulting in false positives. Field and laboratory blanks identify this problem by determining the level and point of contamination. Sample matrix interferences also cause false positives. High spike recoveries indicate that matrix interference has occurred.

- If a chemical of potential concern has been detected in any of the blanks, the probability of false positives associated with that analyte is high. False positives should be suspected for any sample value less than five times the blank concentration (ten times for common laboratory contaminants). High spike recoveries compound problems with blank contamination and increase the likelihood of false positives.
- If chemicals of potential concern are detected in the blanks and spike recoveries for any analyte are biased high, the probability of false positives for that analyte is directly related to the amount of bias. The probability of false positives is highest when the reported concentration is near the detection limit for an analyte.
- If chemicals of potential concern have not been detected in any of the blanks and spike recoveries are not biased high, the probability of false positives is low.

6.1.2 ARE SITE CONCENTRATIONS SUFFICIENTLY DIFFERENT FROM BACKGROUND?

Background samples serve as a baseline measurement to determine the degree of contamination. Background samples are collected and analyzed for each medium of concern in the same manner as other site samples. They require the same degree of quality control and data review. Background samples differ from other samples because the sampling location, as defined in the sampling and analysis plan (SAP), is intended to be in an area that has not been exposed to the source of contamination. Exhibit 6-2 lists the criteria from the Data Useability Worksheet that affect this decision.

As part of the risk assessment process, the risk assessor must determine if the samples collected as background samples are actually uncontaminated. If chemicals of potential concern are

EXHIBIT 6-2

DATA USEABILITY CRITERIA AFFECTING BACKGROUND LEVEL COMPARISON

Worksheet Reference	Data Useability Criterion	Data Collection and Evaluation Decision
1	Reports to risk assessor	Are site concentrations sufficiently different from background?
2A	Documentation (SAP)	
3A	Data sources (analytical)	
6A	Completeness (sampling)	
6B	Comparability (analytical)	
6D	Precision (analytical)	
6E	Accuracy (sampling and analytical)	

not found in the background samples, the entire data collection process will be simplified. If chemicals of potential concern are found in the background samples, the risk assessor must determine whether they are at naturally occurring levels, are of anthropogenic origin, are due to contamination during the sampling process, or if they are site contaminants.

Both naturally occurring chemicals and anthropogenic chemicals have significance for risk assessment. Naturally occurring chemicals are those expected at a site in the absence of human influence. Metals are naturally occurring chemicals that are often included in risk analysis. They are generally present in varying concentrations depending on the medium. For example, soils of high organic content, such as humus, would have a low concentration of metals by weight, while soils with a high clay content would contain higher metal levels. Anthropogenic chemicals are defined in RAGS (EPA 1989a) as concentrations of chemicals that are present in the environment due to man-made, non-site sources (e.g., industry, automobiles). Chemicals of anthropogenic origin include organic compounds such as phthalates (plasticizers), DDT, or polycyclic aromatic hydrocarbons and inorganic chemicals such as lead (from automobile exhaust).

- If chemicals of potential concern are found in background samples, they should not be considered naturally occurring. They can be present because they are either site contaminants or are of anthropogenic origin. They also could be a result of contamination during sampling.
- If chemical concentrations in the background samples fall within naturally-occurring levels and there is no risk associated with those levels, the risk assessor may eliminate the chemicals from the risk assessment calculations.
- If chemical concentrations in the background samples are higher than naturally occurring levels, it is an indication of contamination, either site-specific or anthropogenic in nature. The risk assessor may include the analytical data with other site data or perform a separate risk assessment based on best professional judgment.
- Anthropogenic chemicals should not be eliminated from the risk assessment.
- Statistical analysis may be necessary to determine if site levels are distinctly different from those found in the background samples.
- Statistical analysis may also be necessary in those cases where chemicals of potential concern are detected in site samples at very low concentrations. It is difficult to distinguish a difference between background and site sample concentrations at levels close to the detection limit.

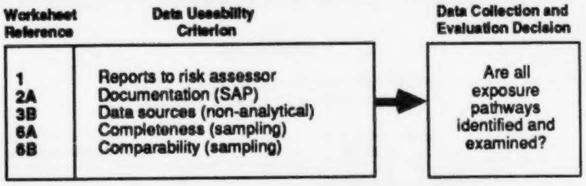
Statistical analysis may be able to determine if site concentrations are significantly above background concentrations when the differences are not obvious.

6.1.3 ARE ALL EXPOSURE PATHWAYS IDENTIFIED AND EXAMINED?

The identification and examination of exposure pathways is discussed in detail in RAGS (EPA 1989a). Exhibit 6-3 summarizes the criteria that the risk assessor must assess to determine the probable level of certainty that all pathways have been identified and examined.

EXHIBIT 6-3

DATA USEABILITY CRITERIA AFFECTING EXPOSURE PATHWAY EXAMINATION



Worksheet Reference	Data Useability Criterion	Data Collection and Evaluation Decision
1	Reports to risk assessor	Are all exposure pathways identified and examined?
2A	Documentation (SAP)	
3B	Data sources (non-analytical)	
6A	Completeness (sampling)	
6B	Comparability (sampling)	

The nature of the pathways to be examined is critical to the selection of a sample design and analytical methods. If the exposure pathways are not identified properly, the resulting characterization will be inappropriate. The risk assessor should determine which pathways are not adequate and determine the effect on the risk assessment if those pathways are excluded from study.

- If additional samples can be collected to include the inadequately represented exposure pathway in the risk assessment, the risk assessor should recommend their acquisition. (Sampling considerations presented in Chapter 3 of this manual should be re-examined).
- If additional samples cannot be collected from an inadequately represented pathway, the risk assessor should investigate whether computer simulation modeling is feasible. For example, if the contamination of the soil and water at the site is fully characterized but no air samples were obtained, air flow models could be used to estimate transport of volatile contaminants.
- If additional samples cannot be collected from an inadequately represented pathway and no simulation models are appropriate, the risk assessor should note in the report that

the risk could not be determined for that pathway or use simple chemical/physical relationships to estimate the exposure. For example, equilibrium partition coefficients can be used to estimate movement in the vadose zone of soil if insufficient data exist to calibrate a groundwater transport model.

6.1.4 ARE ALL EXPOSURE PATHWAYS FULLY CHARACTERIZED?

Assessing how well exposure pathways have been characterized involves evaluation of completeness, comparability, and representativeness across analytical and sampling data quality indicators. Exhibit 6-4 lists the criteria from the worksheet that affect this decision. To be fully characterized, the exposure pathway must have been appropriately sampled. Broad-spectrum analyses also must have been conducted for the media of concern and analyte-specific methods used where appropriate. The uncertainty in the data collection and analysis depends on the evaluation of completeness, comparability and representativeness as discussed in Section 5.6. Based on these indicators, the risk assessor should determine the magnitude of the effect of analytical data uncertainty on the risk assessment.

EXHIBIT 6-4

DATA USEABILITY CRITERIA AFFECTING EXPOSURE PATHWAY CHARACTERIZATION

Worksheet Reference	Data Useability Criterion	Data Collection and Evaluation Decision
1	Reports to risk assessor	Are all exposure pathways fully characterized?
2A	Documentation (SAP)	
2B	Documentation (SOPs)	
2C	Documentation (field records)	
3A	Data sources (analytical)	
3B	Data sources (non-analytical)	
6A	Completeness (sampling and analytical)	
6B	Comparability (sampling and analytical)	
6C	Representativeness (sampling and analytical)	
6D	Precision (sampling)	

- If the uncertainty associated with the data for an exposure pathway is not significant, the risk assessor should use the data and note in the report the high level of certainty associated with assessment of the affected exposure pathway.
- If the uncertainty associated with the data for any exposure pathway is significant but does not warrant resampling and reanalysis, statistical procedures may be necessary to interpret the data.
- If the uncertainty associated with the data is high, the risk assessor may determine that an exposure pathway is not fully characterized.

6.2 Assessment of Uncertainty Associated With the Baseline Risk Assessment for Human Health

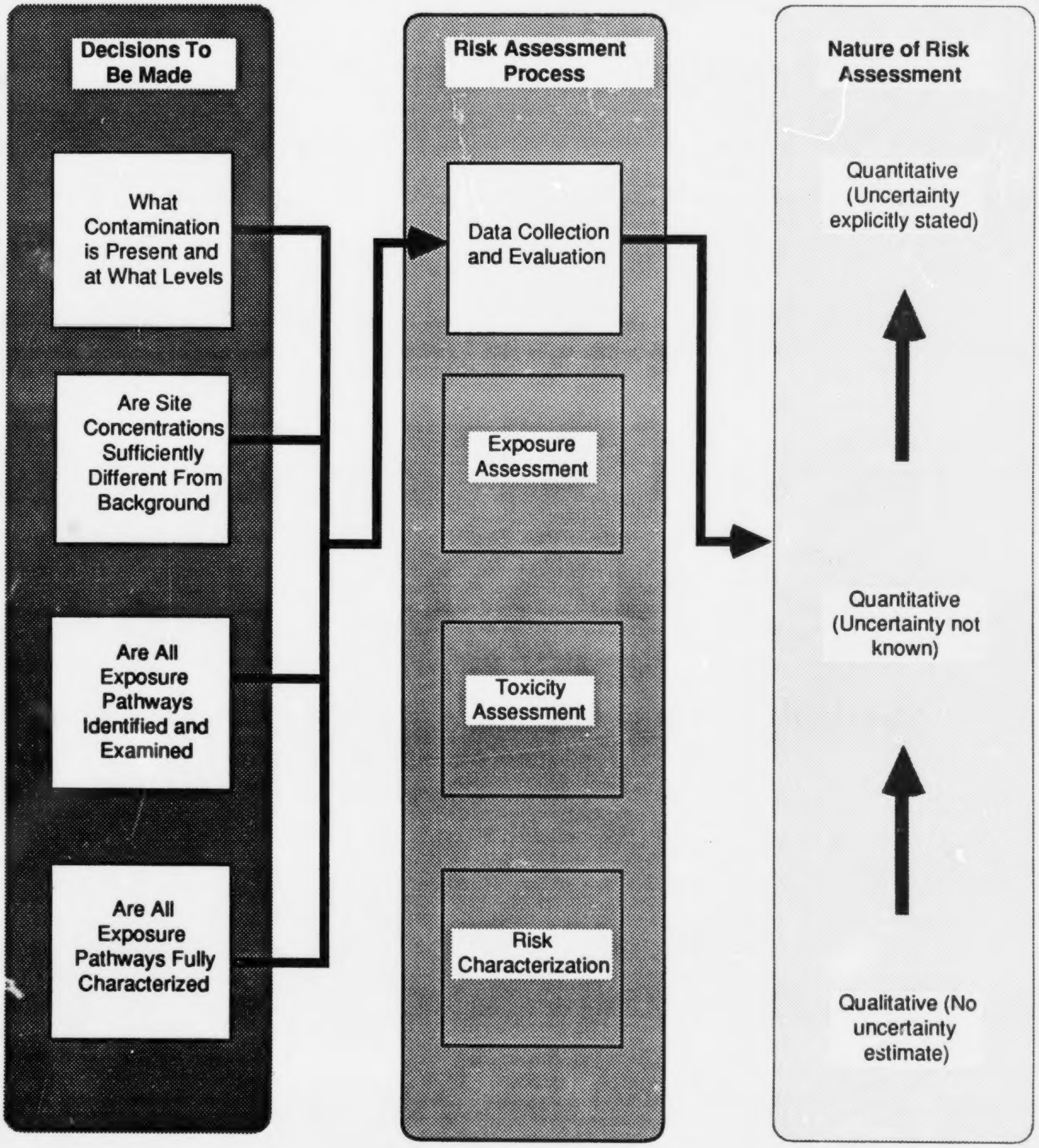
The level of certainty in making each of the four decisions discussed in Section 6.1 contributes to the overall uncertainty in the data collection and analysis component of the risk assessment. The critical factor in assessing the effect of uncertainty on the environmental analytical data component of the risk assessment is not that uncertainty exists, but rather that the risk assessor be able to qualify and/or quantify the uncertainty. The certainty levels for risk assessment represented in Exhibit 6-5 are based on the ability to quantify the uncertainty in analytical data collection and evaluation. Data collection and evaluation, however, comprise only one source of uncertainty in the risk assessment. Other components of the risk assessment process, such as toxicity of chemicals and exposure assumptions, influence the four decisions to be made and contribute significantly to the uncertainty of the baseline risk assessment.

The most quantitative level of risk assessment occurs when the uncertainty in the data can be determined quantitatively. The next level occurs when the uncertainty can be determined qualitatively, or the impact of the uncertainty is assessed using sensitivity analysis. The least desirable situation occurs when the uncertainty in the data is unknown. This situation can occur if the minimum requirements given in Chapter 5 for the data useability criteria have not been achieved.

The primary planning objective is that uncertainty levels are acceptable, known and quantifiable, not that uncertainty be eliminated.

EXHIBIT 6-5

UNCERTAINTY IN DATA COLLECTION AND EVALUATION DECISIONS AFFECTS THE CERTAINTY OF THE RISK ASSESSMENT


Decisions To Be Made
What Contamination is Present and at What Levels
Are Site Concentrations Sufficiently Different From Background
Are All Exposure Pathways Identified and Examined
Are All Exposure Pathways Fully Characterized
Risk Assessment Process
Data Collection and Evaluation
Exposure Assessment
Toxicity Assessment
Risk Characterization
Nature of Risk Assessment
Quantitative (Uncertainty explicitly stated)
Quantitative (Uncertainty not known)
Qualitative (No uncertainty estimate)

GLOSSARY

Accuracy. A measure of the closeness of an observed concentration to the true value.

Aliquot. A measured portion of a sample or extract taken for analysis.

Analyte. One of the chemicals or chemical species for which a sample is analyzed.

Anthropogenic Background Levels. Concentrations of chemicals that are present in the environment due to human-made, non-site sources (i.e., industry, automobiles).

Background Sample. A sample taken from a location where chemicals present in the ambient medium are assumed due to natural sources.

Bias. A measure of overestimation or underestimation of reported values.

Biased Sampling. A sampling plan in which the data obtained may be systematically different from the true mean. Bias in sampling is caused by systematic error in data location, such as clustering data points.

Blank. A clean sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage, or analysis.

Broad Spectrum Analysis. An analytical procedure capable of providing identification and quantitation of a wide variety of potential chemicals.

Calibration. The comparison of a measurement standard or instrument with another standard or instrument to report or eliminate, by adjustment, any variation (deviation) in accuracy of the item being compared. The levels of calibration standards should bracket the range of levels for which actual measurements are to be made.

Chemical of Potential Concern. Chemical initially identified or suspected to be present at a site that may be hazardous to human health.

Chromatogram. The plot of a detector response as a function of time that represents the separation of compounds during analysis.

Classical Statistics. The theory of statistics that assumes that data points are mutually independent. Classical methods consider that one point is not related to another.

Co-elution. When the time of release of two or more analytes from the column of a gas chromatograph cannot be distinguished.

Co-extractable. When two or more analytes are released from the matrix under sample preparation conditions.

Coefficient of Variation. A measure of relative dispersion (precision) used in parametric statistics. It is equal to the standard deviation divided by the mean, multiplied by 100 and is expressed as a percentage.

Collocated Sample. Independent samples that are equally representative of the parameters of interest at a given point in space and time.

Comparability. A measure of the equivalence of data.

Completeness. A measure of the amount of useable data resulting from a data collection activity, given the sample design and analysis.

Composite Sample. A sample that is combined from several sampling locations in order to reduce cost and provide an estimate of the mean of the population from which the samples are drawn. No estimate of the variance of the mean, and hence, the precision with which the mean is estimated can be obtained from a composite sample.

Compound Class. A group of organic compounds that are structurally related.

Confidence. A measure of the probability of taking action when action is required.

Concentration of Concern. A site-specific level of concentration that the risk assessor determines to be of concern; may be health-based, required by statute or of environmental significance.

Contract Laboratory Program (CLP). Analytical program developed for analysis of Superfund site samples to provide analytical results of know quality, supported by a high level of quality assurance and documentation.

Contract Required Quantitation Limit (CRQL). The chemical specific quantitation levels that the CLP requires to be routinely and reliably quantitated in specified sample matrices.

Data Assessment. The determination of the quantity and quality of data.

Data Quality Indicator (DQI). A performance measure for sampling and analytical procedures.

Data Quality Objectives (DQOs). Qualitative and quantitative statements that specify the quality of the data required to support decisions. DQOs are determined based on the end use of the data to be collected.

Data Review. The evaluation process that determines the quality of reported analytical results. It involves examination of raw data (i.e., instrument output) and quality control and method parameters by a professional with knowledge of the tests performed.

Data Validation. CLP specific evaluation process that examines adherence to performance based acceptance criteria as outlined in the Functional Guidelines for Evaluating Organics or Inorganics Analyses.

Data Useability. The process of assuring or determining whether the quality of the data generated meet their intended use.

Detection Limit. The minimum concentration or weight of analyte that can be detected by a single measurement with a known confidence level.

Digestion. The application of acid and heat to a solution or suspension to bring metals into solution for elemental (inorganics) analysis.

Dilution. Adding solvent to a sample, with analyte concentration higher than the standard calibration curve, to bring the analyte concentration into a quantifiably measurable range.

Dissolved Metals. Metals present in solution rather than sorbed on suspended particles.

Dose-Response Evaluation. The process of quantitatively evaluating toxicity information and characterizing the relationship between the dose of a contaminant administered or received and the incidence of adverse health effects in the exposed populations.

Duplicate. Two samples taken from the same source at the same time and analyzed under identical conditions.

Exposure Pathway. The course of a chemical or physical agent from a source to an exposed organism. Each exposure pathway includes a release from a source, an exposure unit, and an exposure route.

Extractable Organics. Compounds that can be partitioned into an organic solvent from the sample matrix and that are amenable to gas chromatography (CLP designation).

Extraction. The process of releasing compounds from a sample matrix.

False Negative (Type II or beta error). A statement that a substance is not present when the substance is present.

False Positive (Type I or alpha error). A statement that a substance is present when it is not.

Geostatistics. A theory of statistics that recognizes observed concentrations as dependent on one another and governed by physical processes. Geostatistical methods consider the location of data and the size of the site for calculations.

Heterogeneous Distribution. Sample property that is unevenly distributed in the population.

Historical data. Data collected before the remedial investigation.

Holding time. The length of time from the date of sampling to the date of analysis. CLP designates the holding time as the date from laboratory receipt of sample until date of analysis.

Homogeneous Distribution. A sample property that is evenly distributed over the population.

Hot Spot. Location of substantially higher concentration of a chemical of concern than in surrounding areas of a site.

Hydrocarbon. An organic compound composed of carbon and hydrogen.

Identification. Confirmation of the presence of a specific compound or analyte in a sample.

Instrument Detection Limit (IDL). The lowest amount of a substance that can be detected by an instrument without correction for the effects of sample matrix, handling and preparation.

Intake Estimate. A measure of exposure expressed as the mass of a substance in contact with the exchange boundary per unit body weight per unit time.

Integrated Risk Information System (IRIS). An EPA database containing verified RfDs, slope factors, up-to-date health risks and EPA regulatory information for numerous chemicals. IRIS is EPA's preferred source for toxicity information for Superfund.

Internal Standard. A compound added to organic samples and blanks at a known concentration prior to analysis. It is used as the basis for quantitation of target compounds.

Judgmental Sampling. The process of locating sampling points based on the investigator's judgment of where the sample should be taken.

Kriging. A procedure utilizing the covariance function that determines an acceptable spacing for sampling locations on a square grid.

Limit of Detection (LOD). The concentration of a chemical that has a 99 percent probability of producing an analytical result above zero using a specific method.

Limit of Quantitation (LOQ). The concentration of a chemical that has 99 percent probability of producing an analytical result above the LOD. Results below LOQ are not quantitative.

Linearity. The agreement between an actual instrument reading and the reading predicted by a straight line drawn between calibration points that bracket the reading.

Lowest-Observable-Adverse-Effect-Level (LOAEL). In dose experiments, the lowest exposure level at which there are statistically or biologically significant increases in frequency or severity of adverse effects between the exposed population and its apparent control group.

Mass Spectrum. A characteristic pattern of ion fragments of different masses resulting from analysis that can be compared with a mass spectral library for analyte identification.

Matrix/Medium. The predominant material comprising the sample to be analyzed (e.g., drinking water, sludge, air).

Measurement Error. The difference between the true sample value and the observed value.

Method Detection Limit (MDL). The detection limit that takes into account the reagents, sample matrix, and preparation steps applied to a sample in specific analytical methods.

Minimum Detectable Difference. Percent difference between two concentration levels that can be detected in analyses.

Naturally Occurring Background Levels. Ambient concentrations of chemicals that are present in the environment in the absence of human intervention (e.g., aluminum, manganese).

No-Observed-Adverse-Effect-Level (NOAEL). In dose response experiments, an exposure level at which there are no statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.

Noise. The random errors of observation and other uncontrollable effects that are not related to the presence of the analyte being measured.

Nonparametric. Statistical equations that assume the data set is not normally distributed.

Normal Distribution. A probability density function that approximates the distribution of many random variables and has the form generally called the "bell-shaped curve."

Null Hypothesis. For risk assessment, statistical hypothesis that states on-site contaminant concentrations are not higher than background.

Parameter. A specified component of a procedure or method.

Parametric. Statistical equations that assume the data set is normally distributed.

Particulate. Solid material suspended in a fluid (air or water) medium.

Performance Evaluation Sample. A sample of known composition provided for laboratory analysis to monitor laboratory and method performance.

Power. A measure of the probability of taking no action when no action is required.

Precision. A measure of the reproducibility or variability of a measurement under a given set of conditions.

Preservation. The sample treatment for maintaining representative sample properties.

Qualifier. A code appended to an analytical result that indicates possible qualitative or quantitative uncertainty in the result.

Qualitative. An analysis that identifies an analyte in a sample without numerical certainty.

Quantitative. An analysis that gives a numerical level of certainty to the concentration of an analyte in a sample.

Random Sampling. The process of locating sample points randomly within a sampling area.

Reasonable Maximum Exposure (RME). The highest exposure that is reasonably expected to occur at a site.

Recovery. A determination of the accuracy of the analytical procedure made by comparing measured values for a spiked sample against the known spike values.

Reference Dose (RfD). EPA's preferred toxicity value for evaluating noncarcinogenic effects resulting from exposures at Superfund sites.

Representativeness. The extent to which data measure the objectives of the data collection.

Resolution. The degree of difference between two measurements.

Retention Index. Retention time data specific to an analytical gas chromatography column compared with retention times of standards.

Retention Time. The length of time that a compound is retained on an analytical column (GC, HPLC, IC).

Routine Method. A method issued by an organization with appropriate responsibility. A routine method has been validated and published and contains information on minimum performance characteristics.

Sample Integrity. The maintenance of the sample in the same condition as when sampled.

Sample Quantitation Limit (SQL). The detection limit that accounts for sample characteristics, sample preparation and analytical adjustments such as dilution.

Sensitivity. The capability of methodology or instrumentation to discriminate between measurement responses for quantitative differences in a parameter of interest.

Slope factor. A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular level of a potential carcinogen.

Solvent. A liquid used to dissolve and separate analytes from the matrix of origin.

Spatial Variation. Term describing the manner in which contaminants vary as a function of space. The magnitude of difference in contaminant concentrations in samples separated by a known distance is a measure of spatial variability.

Spike. A known amount of a chemical added to a sample for the purpose of determining efficiency of recovery; a type of quality control sample.

Split. A single sample divided for the same measurement by two processes for the purpose of monitoring precision, accuracy or comparability of two analyses.

Standard Deviation. The most common measure of the dispersion of observed values or results expressed as the magnitude of the square root of the variance.

Stratified Random Sampling. The process of locating samples randomly within distinct populations, unit areas or strata.

Stratify. To divide into strata.

Surrogate. A substance added to environmental samples for quality control purposes that is not likely to be found in an environmental sample but that mimics the analyte of interest.

Systematic Random (Grid) Sampling. A non-biased sampling plan using a grid comprised of equidistant parallel lines at right angles to each other.

Target Compound. The compound of interest in a specific method. The term also has been used in the Federal Register to denote compounds of regulatory significance.

Temporal Variation. Variation observed in chemical concentrations that is dependent on time.

Tentatively Identified Compound (TIC). Organic compounds detected in a sample that are not target compounds, internal standards or surrogates.

Toxicological Threshold. The concentration at which a compound exhibits toxic effects.

Turnaround Time. The time from laboratory receipt of samples to receipt of a data package by the client.

95% Upper Confidence Limit (UCL). The upper limit on a normal distribution curve below which the observed mean of a data set will occur 95% of the time.

Useful Range. That portion of the calibration curve that will produce the most accurate and precise results.

Variance. A measure of dispersion. It is the sum of the squares of the difference between the individual values and the arithmetic mean of the set, divided by one less that the number of values.

Viscosity. The physical property of a fluid that offers a continued resistance to flow.

Volatile Organics. The solid or liquid compounds that may undergo spontaneous phase change to a gaseous state at standard temperature and pressure.

Wavelength. The linear distance between successive maximum or minima of a wave form.

Weight-of-Evidence Classification. An EPA classification system for characterizing the extent to which available data indicate that an agent is a human carcinogen. Recently, EPA has developed weight-of-evidence systems for other kinds of toxic effects, such as developmental effects.

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Chapter 1
Introduction and Background

Chapter 2
The Risk Assessment Process

Chapter 3
Criteria for Evaluating Data Useability in Baseline Risk Assessments

Chapter 4
Steps for Planning for the Acquisition of Useable Environmental Data in Baseline Risk Assessments

Chapter 5
Assessment of Environmental Data for Useability in Baseline Risk Assessments

Chapter 6
Application of Data to Baseline Risk Assessments

APPENDICES

APPENDICES

- Provide technical reference tables for sampling and analysis.
- Describe data review packages and meanings of selected data qualifiers.

APPENDIX I
DESCRIPTION OF ORGANICS AND INORGANICS DATA REVIEW PACKAGES

The purpose of Appendix I is to familiarize the reader with a model for data review deliverables. This appendix consists of the following items:

1. A description of the five major components of a typical data review package.
2. An example of a data review summary.
3. Example data review forms.

Please note that the example forms are designed for the validation of Contract Laboratory Program (CLP) type data packages. An example form is included for each analytical fraction (volatiles, semivolatiles, pesticide/aroclors and metals) and for samples from soil/sediment and aqueous matrices. These forms nevertheless include the necessary information for the review of most types of data (analytical results, sample quantitation/detection limits, data qualifiers, etc.) not associated with the CLP.

APPENDIX I
1. DESCRIPTION OF DATA REVIEW PACKAGES

A typical data review package consists of the following components.

- Narrative
- Glossary of Data Qualifiers
- Data Summary Forms
- Analysis Data Sheets for Each Sample
- Support Documentation

Narrative

The Narrative provides sample identification information, and describes the problems found that affect data quality.

Glossary of Data Qualifiers

This glossary is a list of Data Review Qualifiers and their meanings for use in data evaluation.

Data Summary Forms

A Data Summary Form consists of a grid of sample numbers and analytes where all positive results are reported for each analyte in each sample along with the applicable data validation qualifier if present. The Data Summary Forms provide a reference which indicates both position sample results and sample specific quantitation limits.

Analysis Data Sheets for Each Sample

The results of all analytes analyzed from each sample are reported by the laboratory on Analysis Data Sheets. This includes the results of the Laboratory search compounds or Tentatively Identified Compounds for organic analysis. Sample quantitation limits for undetected analytes, and laboratory generated quality control flags are also reported where applicable.

Some data reviewers may mark the results on the Analysis Data Sheets with the appropriate data review qualifiers instead of using Data Summary Forms. Examples of Analysis Data Sheets are given for organics and inorganics data.

Support Documentation

Support Documentation usually included in data review packages are summaries of the quality control results or raw data that have caused the data to be qualified. Documents which discuss data analysis or reporting issues may also be included.

2. DATA REVIEW SUMMARY

ORGANIC DATA SUMMARY FORMS UTILIZED BY REGION III IN THE CLP

DATE:

SUBJECT:

FROM:

TO:

THRU:

OVERVIEW

Case consisted of four (4) low level water and two (2) low level soil samples, submitted for full organic analyses. Included in this data set was one (1) equipment blank and one (1) trip blank. The trip blank was analyzed for volatiles only. The samples were analyzed as a Contract Laboratory Program (CLP) Routine Analytical Service (RAS).

SUMMARY

All samples were successfully analyzed for all target compounds with the exception of 2-Butanone and 2-Hexanone in the volatile fraction. All remaining instrument and method sensitivities were according to the Contract Laboratory Program (CLP) Routine Analytical Service (RAS) protocol.

MAJOR PROBLEM

The response factors (RF) for 2-Butanone and 2-Hexanone were less than 0.05 in one of the continuing volatile calibration. The quantitation limits for this compound in the affected samples were qualified unreliable, "R". (See Table I in Appendix F for the affected samples.)

MINOR PROBLEMS

Several compounds failed precision criteria for initial and/or continuing calibrations. Quantitation limits and the reported results for these compounds may be biased and, therefore, have been qualified estimated, "UJ" and "J", respectively. (See Table I in Appendix F for the affected samples).

2. DATA REVIEW SUMMARY

NOTES

- o The soil semivolatile MS/MSD analyses were originally extracted within the technical and contractual holding times. Re-extractions were required because of surrogate recoveries, and these re-extractions were performed outside of holding times. Surrogate recoveries were again outside of the QC limits, therefore, original sample results are being reported.

- o The maximum concentration of compounds found in the trip blanks, field blanks, or method blanks are listed below. All samples with concentrations of common laboratory contaminants less than ten times (<10X) the blank concentration, and uncommon laboratory contaminants less than five times (<5X) the blank concentration have been qualified "B" in the data summary table. (See Appendix F).

Compound	Concentration (ug/L)
Methylene chloride *	7 J
Acetone *	9 J
Bis(2-ethylhexyl)phthalate *	10 J

* Common Laboratory Contaminant

- o The semivolatile MS/MSD analyses had compounds other than the spiking compounds present. The following is a table of results and precision estimates for the non-spiked compounds:

MS/MSD Non-Spiked Compounds

Compound	Concentration (ug/L)			%RSD
Phenanthrene	150 J	190 J	140 J	16.5
Fluoranthene	340 J	470 J	440 J	16.3
Benzo(a)anthracene	290 J	310 J	320 J	5.0
Chrysene	290 J	330 J	300 J	6.8
Bis (2-ethylhexyl) phthalate	160 J	200 J	240 J	20.0
Benzo (b)pyrene	190 J	240 J	240 J	12.9
Benzo (k) pyrene	230 J	200 J	220 J	7.1
Benzo (a) pyrene	240 J	190 J	240 J	12.9

RSD= Relative Standard Deviation

2. DATA REVIEW SUMMARY

- The pesticide/PCB analyses of all soil samples and associated QC samples had surrogate recoveries in excess of the QC limit. Since no positive results were reported for any pesticide or PCB compounds for any of the samples in this case no data was affected. (See Appendix F).

- The reported Tentatively Identified Compounds (TIC's) in Appendix D have been reviewed and accepted or corrected.

- All data for Case were reviewed in accordance with the Functional Guidelines for Evaluating Organic Analyses with modifications for use within Region III. The text of this report addresses only those problems affecting usability.

ATTACHMENTS

APPENDIX A - Glossary of Data Qualifiers
APPENDIX B - Data Summary. These include:
  (a) All positive results for target compounds with qualifier codes where applicable.
  (b) All unusable detection limits (qualified "R").
APPENDIX C - Results as Reported by the Laboratory for All Target Compounds
APPENDIX D - Reviewed and Corrected Tentatively Identified Compounds
APPENDIX E - Organic Regional Data Assessment Summary
APPENDIX F - Support Documentation

APPENDIX I (Continued)

3. DATA REVIEW FORM

TEMPA2-9

TABLE________

CLP INORGANIC ANALYSIS AQUEOUS SAMPLE DETECTION LIMITS (ug/l)

PAGE __ of __

CERCLIS SITE NAME________________________

CASE No.______________, SDG No.____________

Sample Location												
Sample Number												
Traffic Report Number												
Remarks												
Sampling date												
Analysis Date												
Inorganic Analytes		IDL(ug/L)										
Aluminum	P											
Antimony	P											
Arsenic	F											
Barium	P											
Beryllium	P											
Cadmium	P											
Calcium	P											
Chromium	P											
Cobalt	P											
Copper	P											
Iron	P											
Lead	F											
Magnesium	P											
Manganese	P											
Mercury	CV											
Nickel	P											
Potassium	P											
Selenium	F											
Silver	P											
Sodium	P											
Thallium	F											
Vanadium	P											
Zinc	P											
Cyanide	C											

Analytical Method	UJ The detection limit is approximated due to limitations identified in the quality control review (data validation).
F Furnace AA NOTE:	
P ICP/Flame AA	R Value is rejected.
CV Cold Vapor	NA Not Analyzed.
C Colorimetric	

Sample's wet weight (gms) for Hg analysis for ICP analysis for furnace AA analysis for Cyanide analysis											

APPENDIX I (Continued)

3. DATA REVIEW FORM

TEMPL2-9

TABLE________

CLP INORGANIC ANALYSIS SOIL AND SEDIMENT SAMPLE DETECTION LIMITS (ug/l)

PAGE __ of __

CERCLIS SITE NAME______________________________

CASE No.__________________, SDG No._______________

Sample Location												
Sample Number												
Traffic Report Number												
Remarks												
Sampling date												
Analysis Date												
Percent Solids												
Inorganic Analytes		IDL(ug/L)										
Aluminum	P											
Antimony	P											
Arsenic	F											
Barium	P											
Beryllium	P											
Cadmium	P											
Calcium	P											
Chromium	P											
Cobalt	P											
Copper	P											
Iron	P											
Lead	F											
Magnesium	P											
Manganese	P											
Mercury	CV											
Nickel	P											
Potassium	P											
Selenium	F											
Silver	P											
Sodium	P											
Thallium	F											
Vanadium	P											
Zinc	P											
Cyanide	C											

Analytical Method	UJ The detection limit is approximated due to limitations identified in the quality control review (data validation).
F Furnace AA NOTE:	R Value is rejected.
P ICP/Flame AA	NA Not Analyzed.
CV Cold Vapor	
C Colorimetric	

Sample's wet weight (gms) for Hg analysis for ICP analysis for furnace AA analysis for Cyanide analysis											

APPENDIX I (Continued)

3. DATA REVIEW FORM

TEMPL2-1

TABLE ____

CLP INORGANIC ANALYSIS SOIL ANALYTICAL RESULTS (ug/kg)

PAGE ____ of ____

CERCLIS SITE NAME: ____________________

CASE NO. ____________, SDG NO. ____________

Sample Location												
Sample Number												
Traffic Report Number												
Remarks												
Sampling date												
Inorganic analytes		CRDL										
Aluminum	P	200										
Antimony	P	60										
Arsenic	F	10										
Barium	P	200										
Beryllium	P	5										
Cadmium	P	5										
Calcium	P	5000										
Chromium	P	10										
Cobalt	P	50										
Copper	P	25										
Iron	P	100										
Lead	P	3										
Magnesium	P	5000										
Manganese	P	15										
Mercury	CV	0.2										
Nickel	P	40										
Potassium	P	5000										
Selenium	F	5										
Silver	P	10										
Sodium	P	5000										
Thallium	F	10										
Vanadium	P	50										
Zinc	P	20										
Cyanide	C	10										

Analytical Method			
F	Furnace	J	Quantitation is approximated due to limitations identified during the quality control review.
P	ICP/Flame AA	R	Value is rejected.
CV	Cold Vapor	U	Revised Sample Quantitation Limit.
C	Colorimetric	UJ	Quantitation limit is approximate due to limititations identified in the quality control review.
		NA	Not Analyzed.

Sample results are reported on a dry weight basis.

APPENDIX I (Continued)

3. DATA REVIEW FORM

TEMPL2-7

TABLE________

CLP INORGANIC ANALYSIS AQUEOUS ANALYTICAL RESULTS (ug/l)

PAGE _____ of _____

CERCLIS SITE NAME:______________________________

CASE NO.________________, SDG NO.______________

Sample Location												
Sample Number												
Traffic Report Number												
Remarks												
Sampling date												
Inorganic analytes		CRDL										
Aluminum	P	200										
Antimony	P	60										
Arsenic	F	10										
Barium	P	200										
Beryllium	P	5										
Cadmium	P	5										
Calcium	P	5000										
Chromium	P	10										
Cobalt	P	50										
Copper	P	25										
Iron	P	100										
Lead	P	3										
Magnesium	P	5000										
Manganese	P	15										
Mercury	CV	0.2										
Nickel	P	40										
Potassium	P	5000										
Selenium	F	5										
Silver	P	10										
Sodium	P	5000										
Thallium	F	10										
Vanadium	P	50										
Zinc	P	20										
Cyanide	C	10										

Analytical Method		J	Quantitation is approximated due to limitations identified during the quality control review.
F	Furnace	R	Value is rejected.
P	ICP/Flame AA	U	Revised Sample Quantitation Limit.
CV	Cold Vapor	UJ	Quantitation limit is approximate due to limititations identified in the quality control review.
C	Colorimetric	NA	Not Analyzed.

Sample results are reported on a dry weight basis.

APPENDIX I (Continued)

3. DATA REVIEW FORM

THP2-1-1

TABLE________

CLP VOLATILE ORGANIC ANALYSIS AQUEOUS ANALYTICAL RESULTS (ug/l)

PAGE _____ of

CERCLIS SITE NAME:____________________________

CASE NO.________________, SDG NO.______________

Sample Location											
Sample Number											
Traffic Report Number											
Remarks											
Sampling Date											
Analysis Date											
Volatile Organic Compound	CRQL										
Chloromethane	10										
Bromomethane	10										
Vinyl Chloride	10										
Chloroethane	10										
Methylene Chloride	5										
Acetone	10										
Carbon Disulfide	5										
1,1-Dichloroethene	5										
1,1-Dichloroethane	5										
1,2-Dichloroethene(Total)	5										
Chloroform	5										
1,2-Dichloroethane	5										
2-Butanone	10										
1,1,1-Trichloroethane	5										
Carbon Tetrachloride	5										
Vinyl Acetate	10										
Bromodichloromethane	5										
1,2-Dichloropropane	5										
cis-1,3-Dichloropropene	5										
Trichloroethene	5										
Dibromochloromethane	5										
1,1,2-Trichloroethane	5										
Benzene	5										
trans-1,3-Dichloropropene	5										
Bromoform	5										
4-Methyl-2-pentanone	10										
2-Hexanone	10										
Tetrachloroethene	5										
1,1,2,2-Tetrachloroethane	5										
Toluene	5										
Chlorobenzene	5										
Ethylbenzene	5										
Styrene	5										
Xylene (Total)	5										

CRQL	Contract Required Quantitation Limit.
J	Quantitation is approximate due to limitations identified during the quality control review.
UJ	Quantitation limit is approximated due to limitations identified in the quality control review.
R	Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

THP2-2-1

TABLE________

CLP VOLATILE ORGANIC ANALYSIS SOIL ANALYTICAL RESULTS (ug/kg)

PAGE___ of____

CERCLIS SITE NAME:________________

CASE NO.__________, SDG NO.__________

Sample Location												
Sample Number												
Traffic Report Number												
Remarks												
Sampling Date												
Analysis Date												
Volatile Organic Compound	CRQL											
Chloromethane	10											
Bromomethane	10											
Vinyl Chloride	10											
Chloroethane	10											
Methylene Chloride	5											
Acetone	10											
Carbon Disulfide	5											
1,1-Dichloroethene	5											
1,1-Dichloroethane	5											
1,2-Dichloroethene (Total)	5											
Chloroform	5											
1,2-Dichloroethane	5											
2-Butanone	10											
1,1,1-Trichloroethane	5											
Carbon Tetrachloride	5											
Vinyl Acetate	10											
Bromodichloromethane	5											
1,2-Dichloropropane	5											
cis-1,3-Dichloropropene	5											
Trichloroethene	5											
Dibromochloromethane	5											
1,1,2-Trichloroethane	5											
Benzene	5											
trans-1,3-Dichloropropene	5											
Bromoform	5											
4-Methyl-2-pentanone	10											
2-Hexanone	10											
Tetrachloroethene	5											
1,1,2,2-Tetrachloroethane	5											
Toluene	5											
Chlorobenzene	5											
Ethylbenzene	5											
Styrene	5											
Xylene (Total)	5											

CRQL	Contract Required Quantitation Limit.
J	Quantitation is approximate due to limitations identified during the quality control review.
UJ	Quantitation limit is approximate due to limitations identified in the quality control review
R	Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

THP2-3-1

' TABLE________

CLP VOLATILE ORGANIC ANALYSIS SOIL SAMPLE QUANTITATION LIMITS (ug/kg)

CERCLIS SITE NAME:________________________

CASE NO.______________, SDG NO.____________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Dilution Factor										
Percent Solids										
Volatile Organic Compound										
Chloromethane										
Bromomethane										
Vinyl Chloride										
Chloroethane										
Methylene Chloride										
Acetone										
Carbon Disulfide										
1,1-Dichloroethene										
1,1-Dichloroethane										
1,2-Dichloroethene (Total)										
Chloroform										
1,2-Dichloroethane										
2-Butanone										
1,1,1-Trichloroethane										
Carbon Tetrachloride										
Vinyl Acetate										
Bromodichloromethane										
1,2-Dichloropropane										
cis-1,3-Dichloropropene										
Trichloroethene										
Dibromochloromethane										
1,1,2-Trichloroethane										
Benzene										
trans-1,3-Dichloropropene										
Bromoform										
4-Methyl-2-pentanone										
2-Hexanone										
Tetrachloroethene										
1,1,2,2-Tetrachloroethane										
Toluene										
Chlorobenzene										
Ethylbenzene										
Styrene										
Xylene (Total)										

Sample Quantitation limits are reported on a dry weight basis.

UJ Quantitation limit is approximated due to limitations during the quality control review.

R Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

CLP VOLATILE ORGANIC ANALYSIS AQUEOUS SAMPLE QUANITATION LIMITS (ug/l)

CERCLIS SITE NAME________________________________

CASE No.____________, SDG No.____________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Dilution Factor										
Volatile Organic Compound										
Chloromethane										
Bromomethane										
Vinyl Chloride										
Chloroethane										
Methylene Chloride										
Acetone										
Carbon Disulfide										
1,1-Dichloroethene										
1,1-Dichloroethane										
1,2-Dichloroethene (Total)										
Chloroform										
1,2-Dichloroethane										
2-Butanone										
1,1,1-Trichloroethane										
Carbon Tetrachloride										
Vinyl Acetate										
Bromodichloromethane										
1,2-Dichloropropane										
cis-1,3-Dichloropropene										
Trichloroethene										
Dibromochloromethane										
1,1,2-Trichloroethane										
Benzene										
trans-1,3-Dichloropropene										
Bromoform										
4-Methyl-2-pentanone										
2-Hexanone										
Tetrachloroethene										
1,1,2,2-Tetrachloroethane										
Toluene										
Chlorobenzene										
Ethylbenzene										
Styrene										
Xylene (Total)										

Sample Quantitation limits are reported on a dry weight basis.
UJ Quantitation limit is approximated due to limitations during the quality control review.
R Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

TMP2-4-1

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS AQUEOUS ANALYTICAL RESULTS (ug/l)

PAGE_____OF_____

CERCLIS SITE NAME:______________________________

CASE NO.________________, SDG NO.______________

Sample Location												
Sample Number												
Traffic Report Number												
Remarks												
Sampling Date												
Extraction Date												
Analysis Date												
Semi-Volatile Compound	CRQL											
Phenol	10											
bis (2-Chloroethyl) ether	10											
2-Chlorophenol	10											
1,3-Dichlorobenzene	10											
1,4-Dichlorobenzene	10											
Benzyl Alcohol	10											
1,2-Dichlorobenzene	10											
2-Methylphenol	10											
bis (2-Chloroisopropyl)ether	10											
4-Methylphenol	10											
N-Nitroso-di-n-propylamine	10											
Hexachloroethane	10											
Nitrobenzene	10											
Isophorone	10											
2-Nitrophenol	10											
2,4-Dimethylphenol	10											
Benzoic acid	50											
bis (2-Chloroethoxy) methane	10											
2,4-Dichlorophenol	10											
1,2,4-Trichlorobenzene	10											
Naphthalene	10											
4-Chloroaniline	10											
Hexachlorobutadiene	10											
4-Chloro-3-methylphenol	10											
2-Methylnaphthalene	10											
Hexachlorocyclopentadiene	10											
2,4,6-Trichlorophenol	10											
2,4,5-Trichlorophenol	50											
2-Chloronaphthalene	10											
2-Nitroaniline	50											
Dimethylphthalate	10											
Acenaphthylene	10											
2,6-Dinitrotoluene	10											

CRQL	Contract Required Quantitation Limit.
J	Quantitation is approximate due to limitations identified during the quality control review.
UJ	Quantitation limit is approximated due to limitations identified in the quality control review.
R	Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

TMP2-4-2

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS AQUEOUS ANALYTICAL RESULTS (ug/l)

CERCLIS SITE NAME:________________________

CASE NO.______________, SDG NO.____________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Extraction Date										
Analysis Date										
Semi-Volatile Compound	CRQL									
3-Nitroaniline	50									
Acenaphthene	10									
2,4-Dinitrophenol	50									
4-Nitrophenol	50									
Dibenzofuran	10									
2,4-Dinitrotoluene	10									
Diethylphthalate	10									
4-Chlorophenyl-phenylether	10									
Fluorene	10									
4-Nitroaniline	50									
4,6-Dinitro-2-methylphenol	50									
N-Nitrosodiphenylamine	10									
4-Bromophenyl-phenylether	10									
Hexachlorobenzene	10									
Pentachlorophenol	50									
Phenanthrene	10									
Anthracene	10									
Di-n-butylphthalate	10									
Fluoranthene	10									
Pyrene	10									
Butylbenzylphthalate	10									
3,3'-Dichlorobenzidine	20									
Benzo(a)anthracene	10									
Chrysene	10									
bis(2-Ethylhexyl)phthalate	10									
Di-n-octyl phthalate	10									
Benzo(b)fluoranthene	10									
Benzo(k)fluoranthene	10									
Benzo(a)pyrene	10									
Indeno (1,2,3-cd)pyrene	10									
Dibenz(a,h)anthracene	10									
Benzo(g,h,i)perylene	10									

CRQL	Contract Required Quantitation Limit.
J	Quantitation is approximate due to limitations identified during the quality control review.
UJ	Quantitation limit is approximated due to limitations identified in the quality control review.
R	Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

THP2-4-3

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS AQUEOUS ANALYTICAL RESULTS (ug/l)

CERCLIS SITE NAME:______________________________

CASE NO.________________, SDG NO.______________

Sample Location											
Sample Number											
Traffic Report Number											
Remarks											
Sampling Date											
Extraction Date											
Analysis Date											
Pesticide/PCB Compound	CRQL										
alpha-BHC	0.05										
beta-BHC	0.05										
delta-BHC	0.05										
gamma-BHC (Lindane)	0.05										
Heptachlor	0.05										
Aldrin	0.05										
Heptachlor epoxide	0.05										
Endosulfan I	0.05										
Dieldrin	0.10										
4,4'-DDE	0.10										
Endrin	0.10										
Endosulfan II	0.10										
4,4'-DDD	0.10										
Endosulfan sulfate	0.10										
4,4'-DDT	0.10										
Methoxychlor	0.5										
Endrin ketone	0.10										
alpha-Chlordane	0.5										
gamma-Chlordane	0.5										
Toxaphene	1.0										
Aroclor-1016	0.5										
Aroclor-1221	0.5										
Aroclor-1232	0.5										
Aroclor-1242	0.5										
Aroclor-1248	0.5										
Aroclor-1254	1.0										
Aroclor-1260	1.0										

CRQL	Contract Required Quantitation Limit.
J	Quantitation is approximate due to limitations identified during the quality control review.
UJ	Quantitation limit is approximated due to limitations identified in the quality control review.
R	Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

THP2-4-4

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS AQUEOUS SAMPLE QUANTITATION LIMITS (ug/l)

PAGE_____of_____

CERCLIS SITE NAME:______________________________

CASE NO.________________, SDG NO.________________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Dilution Factor										
Percent Solids										
Semi-Volatile Compound										
3-Nitroaniline										
Acenaphthene										
2,4-Dinitrophenol										
4-Nitrophenol										
Dibenzofuran										
2,4-Dinitrotoluene										
Diethylphthalate										
4-Chlorophenyl-phenylether										
Fluorene										
4-Nitroaniline										
4,6-Dinitro-2-methylphenol										
N-Nitrosodiphenylamine										
4-Bromophenyl-phenylether										
Hexachlorobenzene										
Pentachlorophenol										
Phenanthrene										
Anthracene										
Di-n-butylphthalate										
Fluoranthene										
Pyrene										
Butylbenzylphthalate										
3,3'-Dichlorobenzidine										
Benzo(a)anthracene										
Chrysene										
bis(2-Ethylhexyl)phthalate										
Di-n-octyl phthalate										
Benzo(b)fluoranthene										
Benzo(k)fluoranthene										
Benzo(a)pyrene										
Indeno (1,2,3-cd)pyrene										
Dibenz(a,h)anthracene										
Benzo(g,h,i)perylene										

Sample Quantitation Limits are reported on dry weight basis.
UJ Quantitation Limits are approximate due to limitations identified during the quality control review.
R Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

TABLE ____

CLP EXTRACTABLE ORGANIC ANALYSIS AQUEOUS SAMPLE QUANTITATION LIMITS (ug/l)

PAGE ____ of ____

CERCLIS SITE NAME: ____________________

CASE NO. ____________, SDG NO. ____________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Dilution Factor										
Percent Solids										
Semi-Volatile Compound										
Phenol										
bis (2-Chloroethyl) ether										
2-Chlorophenol										
1,3-Dichlorobenzene										
1,4-Dichlorobenzene										
Benzyl Alcohol										
1,2-Dichlorobenzene										
2-Methylphenol										
bis (2-Chloroisopropyl)ether										
4-Methylphenol										
N-Nitroso-di-n-propylamine										
Hexachloroethane										
Nitrobenzene										
Isophorone										
2-Nitrophenol										
2,4-Dimethylphenol										
Benzoic acid										
bis (2-Chloroethoxy) methane										
2,4-Dichlorophenol										
1,2,4-Trichlorobenzene										
Naphthalene										
4-Chloroaniline										
Hexachlorobutadiene										
4-Chloro-3-methylphenol										
2-Methylnaphthalene										
Hexachlorocyclopentadiene										
2,4,6-Trichlorophenol										
2,4,5-Trichlorophenol										
2-Chloronaphthalene										
2-Nitroaniline										
Dimethylphthalate										
Acenaphthylene										
2,6-Dinitrotoluene										

Sample Quantitation Limits are reported on a dry weight basis.

UJ Quantitation limit is approximated due to limitations identified in the quality control review.

R Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

TMP2-4-6

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS AQUEOUS SAMPLE QUANTITATION LIMITS (ug/l)

PAGE_____of___

CERCLIS SITE NAME:______________________________

CASE NO.________________, SDG NO.______________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Dilution Factor										
Percent Solids										
Pesticide/PCB Compound										
alpha-BHC										
beta-BHC										
delta-BHC										
gamma-BHC (Lindane)										
Heptachlor										
Aldrin										
Heptachlor epoxide										
Endosulfan I										
Dieldrin										
4,4'-DDE										
Endrin										
Endosulfan II										
4,4'-DDD										
Endosulfan sulfate										
4,4'-DDT										
Methoxychlor										
Endrin ketone										
alpha-Chlordane										
gamma-Chlordane										
Toxaphene										
Aroclor-1016										
Aroclor-1221										
Aroclor-1232										
Aroclor-1242										
Aroclor-1248										
Aroclor-1254										
Aroclor-1260										

Sample Quantitation Limits are reported on dry weight basis.
UJ Quantitation Limits are approximate due to limitations identified during the quality control review.
R Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

THP2-5-1

TABLE______

CLP EXTRACTABLE ORGANIC ANALYSIS SOIL ANALYTICAL RESULTS (ug/kg)

PAGE____of____

CERCLIS SITE NAME:______________________

CASE NO.______________, SDG NO.____________

Sample Location												
Sample Number												
Traffic Report Number												
Remarks												
Sampling Date												
Extraction Date												
Analysis Date												
Semi-Volatile Compound.	CRQL											
Phenol	330											
bis (2-Chloroethyl) ether	330											
2-Chlorophenol	330											
1,3-Dichlorobenzene	330											
1,4-Dichlorobenzene	330											
Benzyl Alcohol	330											
1,2-Dichlorobenzene	330											
2-Methylphenol	330											
bis (2-Chloroisopropyl)ether	330											
4-Methylphenol	330											
N-Nitroso-di-n-propylamine	330											
Hexachloroethane	330											
Nitrobenzene	330											
Isophorone	330											
2-Nitrophenol	330											
2,4-Dimethylphenol	330											
Benzoic acid	1600											
bis (2-Chloroethoxy) methane	330											
2,4-Dichlorophenol	330											
1,2,4-Trichlorobenzene	330											
Naphthalene	330											
4-Chloroaniline	330											
Hexachlorobutadiene	330											
4-Chloro-3-methylphenol	330											
2-Methylnaphthalene	330											
Hexachlorocyclopentadiene	330											
2,4,6-Trichlorophenol	330											
2,4,5-Trichlorophenol	1600											
2-Chloronaphthalene	330											
2-Nitroaniline	1600											
Dimethylphthalate	330											
Acenaphthylene	330											
2,6-Dinitrotoluene	330											

CRQL	Contract Required Quantitation Limit.
J	Quantitation is approximate due to limitations identified during the quality control review.
UJ	Quantitation is approximate due to limitations identified during the quality control review.
R	Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

TMP2-5-2

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS SOIL ANALYTICAL RESULTS (ug/kg)

PAGE____of___

CERCLIS SITE NAME:________________________

CASE NO.______________, SDG NO.______________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Extraction Date										
Analysis Date										
Semi-volatile compound	CRQL									
3-Nitroaniline	1600									
Acenaphthene	330									
2,4-Dinitrophenol	1600									
4-Nitrophenol	1600									
Dibenzofuran	330									
2,4-Dinitrotoluene	330									
Diethylphthalate	330									
4-Chlorophenyl-phenylether	330									
Fluorene	330									
4-Nitroaniline	1600									
4,6-Dinitro-2-methylphenol	1600									
N-Nitrosodiphenylamine	330									
4-Bromophenyl-phenylether	330									
Hexachlorobenzene	330									
Pentachlorophenol	1600									
Phenanthrene	330									
Anthracene	330									
Di-n-butylphthalate	330									
Fluoranthene	330									
Pyrene	330									
Butylbenzylphthalate	330									
3,3'-Dichlorobenzidine	660									
Benzo(a)anthracene	330									
Chrysene	330									
bis(2-Ethylhexyl)phthalate	330									
Di-n-octyl phthalate	330									
Benzo(b)fluoranthene	330									
Benzo(k)fluoranthene	330									
Benzo(a)pyrene	330									
Indeno (1,2,3-cd)pyrene	330									
Dibenz(a,h)anthracene	330									
Benzo(g,h,i)perylene	330									

CRQL Contract Required Detection Limit.
J Quantitation is approximate due to limitations identified during the quality control review.
UJ Quantitation limit is approximte due to limitations identified in the quality control review.
R Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

TMP2-5-3

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS SOIL ANALYTICAL RESULTS (ug/kg)

PAGE___of___

CERCLIS SITE NAME:______________________

CASE NO.______________, SDG NO.____________

Sample Location												
Sample Number												
Traffic Report Number												
Remarks												
Sampling Date												
Extraction Date												
Analysis Date												
Pesticide/PCB Compond	CRQL											
alpha-BHC	8.0											
beta-BHC	8.0											
delta-BHC	8.0											
gamma-BHC (Lindane)	8.0											
Heptachlor	8.0											
Aldrin	8.0											
Heptachlor epoxide	8.0											
Endosulfan I	8.0											
Dieldrin	16.0											
4,4'-DDE	16.0											
Endrin	16.0											
Endosulfan II	16.0											
4,4'-DDD	16.0											
Endosulfan sulfate	16.0											
4,4'-DDT	16.0											
Methoxychlor	80.0											
Endrin ketone	16.0											
alpha-Chlordane	80.0											
gamma-Chlordane	80.0											
Toxaphene	160.0											
Aroclor-1016	80.0											
Aroclor-1221	80.0											
Aroclor-1232	80.0											
Aroclor-1242	80.0											
Aroclor-1248	80.0											
Aroclor-1254	160.0											
Aroclor-1260	160.0											

CRQL Contract Required Quantitation Limit.
J Quantitation is approximate due to limitations identified during the quality control review.
UJ Quantitation is approximate due to limitations identified in the quality control review.
R Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

THP2-6-1

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS SOIL SAMPLE QUANTITATION LIMITS (ug/kg)

PAGE____of____

CERCLIS SITE NAME:________________________

CASE NO.______________, SDG NO.____________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Dilution Factor										
Percent Solids										
Semi-Volatile Compound										
Phenol										
bis (2-Chloroethyl) ether										
2-Chlorophenol										
1,3-Dichlorobenzene										
1,4-Dichlorobenzene										
Benzyl Alcohol										
1,2-Dichlorobenzene										
2-Methylphenol										
bis (2-Chloroisopropyl)ether										
4-Methylphenol										
N-Nitroso-di-n-propylamine										
Hexachloroethane										
Nitrobenzene										
Isophorone										
2-Nitrophenol										
2,4-Dimethylphenol										
Benzoic acid										
bis (2-Chloroethoxy) methane										
2,4-Dichlorophenol										
1,2,4-Trichlorobenzene										
Naphthalene										
4-Chloroaniline										
Hexachlorobutadiene										
4-Chloro-3-methylphenol										
2-Methylnaphthalene										
Hexachlorocyclopentadiene										
2,4,6-Trichlorophenol										
2,4,5-Trichlorophenol										
2-Chloronaphthalene										
2-Nitroaniline										
Dimethylphthalate										
Acenaphthylene										
2,6-Dinitrotoluene										

Sample Quantitation Limits are reported on a dry weight basis.

UJ Quantitation limit is approximated due to limitations identified in the quality control review.

R Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

THP2-6-2

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS SOIL SAMPLE QUANTITATION LIMITS (ug/l)

PAGE____of____

CERCLIS SITE NAME:________________________

CASE NO.____________, SDG NO.____________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Dilution Factor										
Percent Solids										
Semi-Volatile Compound										
3-Nitroaniline Acenaphthene 2,4-Dinitrophenol 4-Nitrophenol Dibenzofuran 2,4-Dinitrotoluene Diethylphthalate 4-Chlorophenyl-phenylether Fluorene 4-Nitroaniline 4,6-Dinitro-2-methylphenol N-Nitrosodiphenylamine 4-Bromophenyl-phenylether Hexachlorobenzene Pentachlorophenol Phenanthrene Anthracene Di-n-butylphthalate Fluoranthene Pyrene Butylbenzylphthalate 3,3'-Dichlorobenzidine Benzo(a)anthracene Chrysene bis(2-Ethylhexyl)phthalate Di-n-octyl phthalate Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(a)pyrene Indeno (1,2,3-cd)pyrene Dibenz(a,h)anthracene . Benzo(g,h,i)perylene										

Sample Quantitation Limits are reported on dry weight basis.

UJ Quantitation Limits are approximate due to limitations identified during the quality control review.

R Value is rejected.

APPENDIX I (Continued)

3. DATA REVIEW FORM

THP2-6-3

TABLE________

CLP EXTRACTABLE ORGANIC ANALYSIS SOIL SAMPLE QUANTITATION LIMITS (ug/l)

PAGE____of____

CERCLIS SITE NAME:________________________

CASE NO.____________, SDG NO.____________

Sample Location										
Sample Number										
Traffic Report Number										
Remarks										
Sampling Date										
Dilution Factor										
Percent Solids										
Pesticide/PCB Compound										
alpha-BHC										
beta-BHC										
delta-BHC										
gamma-BHC (Lindane)										
Heptachlor										
Aldrin										
Heptachlor epoxide										
Endosulfan I										
Dieldrin										
4,4'-DDE										
Endrin										
Endosulfan II										
4,4'-DDD										
Endosulfan sulfate										
4,4'-DDT										
Methoxychlor										
Endrin ketone										
alpha-Chlordane										
gamma-Chlordane										
Toxaphene										
Aroclor-1016										
Aroclor-1221										
Aroclor-1232										
Aroclor-1242										
Aroclor-1248										
Aroclor-1254										
Aroclor-1260										

Sample Quantitation Limits are reported on dry weight basis.

UJ Quantitation Limits are approximate due to limitations identified during the quality control review.

APPENDIX II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES

Appendix II identifies seven industries that generate waste which contains pollutants that are known to pose human and environmental hazards. This appendix is intended to aid the reader in three ways:

- To assist in the identification of target compounds and potential exposure routes.
- To predict associated contaminants that potentially yield interferences.
- To assist in early identification of sites that contain high levels of compounds that may not be included as target analytes for routinely available methods.

The data for these tables were obtained by searching the US EPA Toxic Release Inventory System using the Standard Industrial Classification (SIC) Codes listed below:

	Industry	SIC Code
1	Battery Recycling	3691, 3692
2	Munitions / Explosives	2892
3	Pesticides Manufacturing	2842, 2879
4	Electroplating	59, 3471
5	Wood Preservatives	2491
6	Leather Tanning	3111
7	Petroleum Refining	2911

The appendix consists of seven tables and depicts the pollutants associated with each of the seven industries, the CAS number of each pollutant, and the matrices where each pollutant has been found.

The list is not inclusive of all pollutants or industrial sources. The seven industries were selected based on the recommendation of the Risk Assessment Subgroup of the Data Useability Workgroup because of the frequency of occurrence of the pollutants produced by those industries in Superfund sites.

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 1 : BATTERY RECYCLING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	LEAD	7439921	Y	Y	Y	Y
2	SODIUM SULFATE (SOLUTION)	7757826		Y		
3	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y		Y
4	SULFURIC ACID	7664939	Y	Y		Y
5	AMMONIUM SULFATE (SOLUTION)	7783202		Y		
6	MANGANESE	7439965	Y	Y	Y	Y
7	1,1,1-TRICHLOROETHANE	71556	Y	Y		Y
8	METHANOL	67561	Y	Y		Y
9	FREON 113	76131	Y			Y
10	TRICHLOROETHYLENE	79016	Y	Y		Y
11	TOLUENE	108883	Y			Y
12	ZINC	7440666		Y	Y	Y
13	AMMONIA	7664417	Y	Y		Y
14	CADMIUM	7440439	Y	Y	Y	Y
15	ANTIMONY	7440360	Y	Y		Y
16	BARIUM	7440393	Y	Y		Y
17	NICKEL	7440020	Y	Y	Y	Y
18	FORMALDEHYDE	50000	Y			Y
19	ACETONE	67641	Y			
20	XYLENE (MIXED ISOMERS)	1330207	Y			
21	TETRACHLOROETHYLENE	127184	Y			Y
22	DICHLOROMETHANE	75092	Y			Y
23	PHENOL	108952	Y			Y
24	MERCURY	7439976	Y	Y		Y
25	N-BUTYL ALCOHOL	71363	Y			
26	METHYL ETHYL KETONE	78933	Y			Y
27	METHYL ISOBUTYL KETONE	108101	Y			
28	HYDROCHLORIC ACID	7647010	Y	Y		
29	NITRIC ACID	7697372	Y			Y
30	1,1,1-TRICHLOROETHANE (METHYL CHLOROFORM)	71556	Y			
31	COBALT	7440484	Y		Y	Y
32	ARSENIC	7440382	Y			Y
33	COPPER	7440508		Y		Y
34	SILVER	7440224	Y	Y		Y
35	ACETONITRILE	75058	Y			

---

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 2 : MUNITIONS/EXPLOSIVES

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	ACETONE	67641	Y	Y	Y	Y
2	NITRIC ACID	7697372	Y	Y	Y	Y
3	AMMONIUM NITRATE (SOLUTION)	6484522	Y	Y	Y	Y
4	PENTACHLOROPHENOL	87865			Y	
5	SODIUM SULFATE (SOLUTION)	7757826		Y		
6	AMMONIA	7664417	Y	Y	Y	
7	SULFURIC ACID	7664939	Y	Y	Y	Y
8	METHYL ETHYL KETONE	78933	Y			Y
9	CYCLOHEXANE	110827	Y			Y
10	CHLORINE	7782505	Y	Y		
11	NITROGLYCERIN	55630	Y	Y	Y	Y
12	DICHLOROMETHANE	75092	Y			Y
13	CALCIUM CYANAMIDE	156627	Y		Y	
14	LEAD	7439921	Y	Y	Y	Y
15	ETHYLENE GLYCOL	107211	Y	Y	Y	
16	N-BUTYL ALCOHOL	71363	Y			
17	TERT-BUTYL ALCOHOL	75650	Y			Y
18	M-XYLENE	108383	Y			
19	METHANOL	67561	Y	Y		Y
20	ASBESTOS (FRIABLE)	1332214				Y
21	1,1,1-TRICHLOROETHANE	71556	Y			Y
22	POLYCHLORINATED BIPHENYLS	1336363				Y
23	COPPER	7440508	Y	Y	Y	Y
24	ALUMINUM	7429905	Y	Y	Y	Y
25	2,4-DINITROTOLUENE	121142	Y	Y		
26	GLYCOL ETHERS	79141	Y			
27	BENZENE	71432	Y	Y	Y	Y
28	BIS(2-ETHYLHEXYL) ADIPATE	103231		Y		
29	ZINC	7440666	Y			
30	DIBUTYL PHTHALATE	84742	Y	Y	Y	
31	SODIUM HYDROXIDE (SOLUTION)	1310732	Y		Y	
32	DIETHYL PHTHALATE	84662		Y		

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[a] Rank = Order of Frequency of Occurrence
[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 3 : PESTICIDES MANUFACTURING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	SODIUM SULFATE (SOLUTION)	7757826		Y	Y	Y
2	AMMONIA	7664417	Y	Y	Y	Y
3	TOLUENE	108883	Y	Y	Y	Y
4	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y	Y	Y
5	TITANIUM TETRACHLORIDE	7550450				Y
6	METHANOL	67561	Y	Y	Y	Y
7	DICHLOROMETHANE	75092	Y	Y	Y	Y
8	XYLENE (MIXED ISOMERS)	1330207	Y	Y	Y	Y
9	CHLOROBENZENE	108907	Y	Y		Y
10	HYDROCHLORIC ACID	7647010	Y	Y	Y	Y
11	CHLOROPHENOLS	106489	Y	Y	Y	Y
12	STYRENE	100425	Y	Y		Y
13	ACRYLONITRILE	107131	Y	Y		Y
14	FORMALDEHYDE	50000	Y	Y	Y	Y
15	CARBON TETRACHLORIDE	56235	Y	Y	Y	Y
16	CHLOROTHALONIL	1897456	Y	Y		Y
17	1,2-DICHLOROETHANE	107062	Y	Y	Y	Y
18	ACETONE	67641	Y	Y	Y	Y
19	HEXACHLOROBENZENE	118741	Y	Y		Y
20	1,1,1-TRICHLOROETHANE	71556	Y	Y		Y
21	ETHYLENE GLYCOL	107211	Y	Y	Y	Y
22	GLYCOL ETHERS	79141	Y	Y	Y	Y
23	1,3-BUTADIENE	106990	Y	Y		Y
24	CHLOROMETHANE	74873	Y			Y
25	CAPTAN	133062	Y		Y	Y
26	TETRACHLOROETHYLENE	127184	Y	Y	Y	Y
27	CHLORINE	7782505	Y	Y	Y	Y
28	CARBARYL	63252	Y	Y		Y
29	COPPER	7440508	Y	Y	Y	Y
30	PARATHION	56382	Y			Y
31	ZINEB	12122677				Y
32	PYRIDINE	110861	Y	Y		
33	AMMONIUM NITRATE (SOLUTION)	6484522		Y		
34	PHOSPHORIC ACID	7664382	Y	Y	Y	Y
35	CARBON DISULFIDE	75150	Y		Y	
36	1,2,4-TRICHLOROBENZENE	120821	Y		Y	Y
37	SULFURIC ACID	7664939	Y	Y	Y	Y
38	MALEIC ANHYDRIDE	108316	Y		Y	Y
39	ETHYLBENZENE	100414	Y	Y		Y
40	2,4-D	94757	Y	Y	Y	Y
41	BROMOMETHANE	74839	Y			
42	SEC-BUTYL ALCOHOL	78922	Y	Y		
43	LEAD	7439921				Y
44	CUMENE	98828	Y	Y		Y
45	M-XYLENE	108383	Y			Y
46	ASBESTOS (FRIABLE)	1332214			Y	Y
47	FREON 113	76131	Y			Y
48	DICHLOROBENZENE (MIXED ISOMERS)	25321226	Y		Y	Y
49	CYCLOHEXANE	110827	Y		Y	Y

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[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 3 : PESTICIDES MANUFACTURING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
50	2,4-DICHLOROPHENOL	120832			Y	Y
51	1,4-DICHLOROBENZENE	106467	Y			
52	DICHLOROBROMOMETHANE	75274	Y			Y
53	TRIFLURALIN	1582098	Y	Y	Y	Y
54	1,2,4-TRIMETHYLBENZENE	95636	Y	Y		Y
55	METHYL ISOBUTYL KETONE	108101	Y	Y		Y
56	1,4-DIOXANE	123911	Y			Y
57	NITRIC ACID	7697372	Y	Y		Y
58	N-BUTYL ALCOHOL	71363	Y	Y		Y
59	FLUOMETURON	2164172	Y	Y		Y
60	2-METHOXYETHANOL	109864				Y
61	BIS(2-ETHYLHEXYL) ADIPATE	103231	Y			Y
62	PHENOL	108952	Y	Y		Y
63	ACRYLIC ACID	79107	Y		Y	Y
64	QUINTOZENE	82688	Y			Y
65	ALUMINUM	1344281	Y	Y	Y	Y
66	BENZOYL PEROXIDE	94360			Y	Y
67	O-XYLENE	95476	Y			
68	CHROMIUM	7440473	Y	Y		Y
69	2-PHENYLPHENOL	90437	Y	Y		
70	HYDROGEN CYANIDE	74908	Y	Y		Y
71	ZINC	7440666	Y	Y	Y	Y
72	HEXACHLOROCYCLOPENTADIENE	77474				Y
73	DICOFOL	115322	Y			Y
74	BIPHENYL	92524	Y	Y		Y
75	4-NITROPHENOL	100027	Y		Y	Y
76	METHYL ETHYL KETONE	78933	Y			Y
77	TRICHLOROETHYLENE	79016	Y		Y	
78	M-CRESOL	108394	Y			Y
79	TETRACHLORVINPHOS	961115				Y
80	DI(2-ETHYLHEXYL) PHTHALATE (DEHP)	117817		Y		Y
81	TEREPHTHALIC ACID	100210	Y			Y
82	DICHLORVOS	62737	Y			Y
83	MANEB	12427382	Y			Y
84	P-XYLENE	106423	Y			Y
85	METHYLENE BROMIDE	74953	Y			
86	CHLORAMBEN	133904	Y			Y
87	BENZENE	71432	Y			Y
88	HYDROGEN FLUORIDE	7664393	Y	Y		
89	ETHYLENE	74851	Y			
90	C.I. ACID BLUE 9, DISODIUM SALT	3844459		Y		Y
91	DIMETHYL SULFATE	77781	Y			
92	ISOPROPYL ALCOHOL	67630	Y			
93	HYDRAZINE	302012	Y	Y		
94	VINYL CHLORIDE	75014	Y			
95	METHYLENEBIS(PHENYLISOCYANATE)	101688	Y			Y
96	EPICHLOROHYDRIN	106898	Y			
97	PROPYLENE	115071	Y			
98	NITRILOTRIACETIC ACID	139139		Y		

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[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 3 : PESTICIDES MANUFACTURING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
99	ARSENIC	7440382	Y			Y
100	NAPHTHALENE	91203	Y	Y		
101	VINYLIDENE CHLORIDE	75354	Y			
102	TRICHLORFON	52686	Y			Y
103	DIBUTYL PHTHALATE	84742		Y		
104	ANILINE	62533	Y	Y		
105	METHOXYCHLOR	72435	Y	Y		Y
106	DIETHANOLAMINE	111422	Y	Y	Y	Y
107	NITROBENZENE	98953	Y	Y		
108	CYANIDE COMPOUNDS	57125	Y	Y		
109	AMMONIUM SULFATE (SOLUTION)	7783202		Y		
110	LINDANE	58899	Y			Y
111	POLYCHLORINATED BIPHENYLS	1336363	Y			Y
112	PROPYLENE OXIDE	75569	Y			
113	2,4-DINITROPHENOL	51285	Y	Y		Y
114	PHOSGENE	75445	Y			
115	HEXACHLOROETHANE	67721	Y			
116	CADMIUM	7440439				Y
117	ETHYLENE OXIDE	75218	Y			
118	BENZYL CHLORIDE	100447	Y	Y		
119	4,6-DINITRO-O-CRESOL	534521	Y			
120	CHLOROBENZILATE	510156	Y			

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[a] Rank = Order of Frequency of Occurrence
[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 4 : ELECTROPLATING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	SULFURIC ACID	7664939	Y	Y	Y	Y
2	HYDROCHLORIC ACID	7647010	Y	Y	Y	Y
3	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y	Y	Y
4	1,1,1-TRICHLOROETHANE	71556	Y	Y	Y	Y
5	SODIUM SULFATE (SOLUTION)	7757826	Y	Y		Y
6	NITRIC ACID	7697372	Y	Y	Y	Y
7	DICHLOROMETHANE	75092	Y	Y		Y
8	NICKEL	7440020	Y	Y	Y	Y
9	TRICHLOROETHYLENE	79016	Y	Y		Y
10	CHROMIUM	7440473	Y	Y	Y	Y
11	TETRACHLOROETHYLENE	127184	Y	Y	Y	Y
12	METHYL ETHYL KETONE	78933	Y	Y		Y
13	ZINC	7440666	Y	Y	Y	Y
14	FREON 113	76131	Y		Y	Y
15	ALUMINUM	1344281	Y	Y	Y	Y
15	ALUMINUM	7429905	Y	Y	Y	Y
16	COPPER	7440508	Y	Y	Y	Y
17	PHOSPHORIC ACID	7664382	Y	Y	Y	Y
18	TOLUENE	108883	Y	Y	Y	Y
19	LEAD	7439921	Y	Y	Y	Y
20	XYLENE (MIXED ISOMERS)	1330207	Y			Y
21	ACETONE	67641	Y	Y		Y
22	CADMIUM	7440439		Y	Y	Y
23	ETHYLBENZENE	100414	Y			Y
24	ETHYLENE GLYCOL	107211	Y	Y	Y	Y
25	CYANIDE COMPOUNDS	57125	Y	Y	Y	Y
26	AMMONIA	7664417	Y	Y		Y
27	FORMALDEHYDE	50000	Y	Y		Y
28	GLYCOL ETHERS	79141	Y	Y		Y
29	CHLORINE	7782505	Y	Y		Y
30	METHANOL	67561	Y	Y		Y
31	ETHYLENE OXIDE	75218	Y			
32	METHYL ISOBUTYL KETONE	108101	Y			Y
33	2-METHOXYETHANOL	109864	Y			Y
34	HYDROGEN FLUORIDE	7664393	Y	Y		Y
35	PHENOL	108952	Y			Y
36	1,2-DICHLOROBENZENE	95501	Y			Y
37	N-BUTYL ALCOHOL	71363	Y			Y
38	TERT-BUTYL ALCOHOL	75650	Y			
39	BARIUM	7440393				Y
40	VINYLIDENE CHLORIDE	75354	Y			
41	2-ETHOXYETHANOL	110805	Y			Y
42	ISOPROPYL ALCOHOL	67630	Y			
43	MANGANESE	7439965	Y			Y
44	HYDROGEN CYANIDE	74908				Y
45	STYRENE	100425	Y			
46	TETRACHLORVINPHOS	961115	Y			
47	MELAMINE	108781				Y
48	N-DIOCTYL PHTHALATE	117840				Y

[a] Rank = Order of Frequency of Occurrence
[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 4 : ELECTROPLATING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
49	1,4-DIOXANE	123911	Y			
50	COBALT	7440484		Y		
51	NAPHTHALENE	91203				Y
52	AMMONIUM SULFATE (SOLUTION)	7783202				Y
53	SILVER	7440224		Y		Y
54	PROPYLENE	115071	Y			

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[a] Rank = Order of Frequency of Occurrence
[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 5 : WOOD PRESERVATION

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	CHROMIUM	7440473	Y	Y	Y	Y
2	NAPHTHALENE	91203	Y	Y	Y	Y
3	AMMONIA	7664417	Y		Y	Y
4	PENTACHLOROPHENOL	87865	Y	Y	Y	Y
5	DIBENZOFURAN	132649	Y	Y	Y	Y
6	ANTHRACENE	120127	Y	Y	Y	Y
7	COPPER	7440508	Y	Y	Y	Y
8	ARSENIC	7440382	Y	Y	Y	Y
9	FORMALDEHYDE	50000	Y			
10	BIPHENYL	92524	Y	Y	Y	Y
11	BENZENE	71432	Y	Y		
12	DICHLOROMETHANE	75092	Y			
13	1,1,1-TRICHLOROETHANE	71556	Y			Y
14	AMMONIUM SULFATE (SOLUTION)	7783202		Y	Y	
15	QUINOLINE	91225	Y	Y	Y	Y
16	PHENOL	108952	Y	Y		
17	ZINC	7440666	Y	Y		Y
18	PHOSPHORIC ACID	7664382	Y			
19	O-CRESOL	95487	Y	Y		
20	HYDROCHLORIC ACID	7647010	Y			
21	M-CRESOL	108394	Y	Y		

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[a] Rank = Order of Frequency of Occurrence
[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 6 : LEATHER TANNING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	AMMONIUM SULFATE (SOLUTION)	7783202	Y	Y	Y	Y
2	SULFURIC ACID	7664939	Y	Y		Y
3	SODIUM HYDROXIDE (SOLUTION)	1310732		Y		Y
4	AMMONIA	7664417	Y	Y	Y	Y
5	TOLUENE	108883	Y			Y
6	SODIUM SULFATE (SOLUTION)	7757826		Y		
7	METHYL ETHYL KETONE	78933	Y			Y
8	XYLENE (MIXED ISOMERS)	1330207	Y	Y		Y
9	CHROMIUM	7440473	Y	Y	Y	Y
10	GLYCOL ETHERS	79141	Y	Y		Y
11	METHYL ISOBUTYL KETONE	108101	Y	Y		Y
12	2-METHOXYETHANOL	109864	Y	Y		Y
13	ACETONE	67641	Y	Y		Y
14	2-ETHOXYETHANOL	110805	Y	Y		Y
15	N-BUTYL ALCOHOL	71363	Y	Y		Y
16	TETRACHLOROETHYLENE	127184	Y	Y		
17	CYCLOHEXANE	110827	Y			Y
18	AMMONIUM NITRATE (SOLUTION)	6484522			Y	
19	MANGANESE	7439965		Y	Y	Y
20	1,1,1-TRICHLOROETHANE	71556	Y			
21	DICHLOROMETHANE	75092	Y			
22	DIETHANOLAMINE	111422	Y			Y
23	METHANOL	67561	Y	Y		
24	ISOPROPYL ALCOHOL	67630	Y			Y
25	PHOSPHORIC ACID	7664382		Y		
26	ETHYLENE GLYCOL	107211	Y			
27	FREON 113	76131	Y			
28	PHENOL	108952		Y		
29	ETHYL ACRYLATE	140885	Y			

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[a] Rank = Order of Frequency of Occurrence
[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 7 : PETROLEUM REFINING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	SODIUM SULFATE (SOLUTION)	7757826	Y	Y	Y	Y
2	ALUMINUM	1344281	Y	Y	Y	Y
2	ALUMINUM	7429905	Y	Y	Y	Y
3	AMMONIA	7664417	Y	Y	Y	Y
4	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y	Y	Y
5	SULFURIC ACID	7664939	Y	Y	Y	Y
6	TOLUENE	108883	Y	Y	Y	Y
7	XYLENE (MIXED ISOMERS)	1330207	Y	Y	Y	Y
8	BENZENE	71432	Y	Y	Y	Y
9	METHYL ETHYL KETONE	78933	Y	Y	Y	Y
10	PROPYLENE	115071	Y	Y		Y
11	PHENOL	108952	Y	Y	Y	Y
12	DIETHANOLAMINE	111422	Y	Y	Y	Y
13	ETHYLENE	74851	Y	Y		Y
14	METHANOL	67561	Y	Y	Y	Y
15	CYCLOHEXANE	110827	Y	Y	Y	Y
16	1,2,4-TRIMETHYLBENZENE	95636	Y	Y	Y	Y
17	ETHYLBENZENE	100414	Y	Y	Y	Y
18	PHOSPHORIC ACID	7664382	Y	Y	Y	Y
19	CHROMIUM	7440473	Y	Y	Y	Y
20	METHYL TERT-BUTYL ETHER	1634044	Y	Y	Y	Y
21	ASBESTOS (FRIABLE)	1332214			Y	Y
22	P-XYLENE	106423	Y	Y	Y	Y
23	AMMONIUM SULFATE (SOLUTION)	7783202		Y		Y
24	M-XYLENE	108383	Y	Y	Y	Y
25	CUMENE	98828	Y	Y	Y	Y
26	ACETONE	67641	Y	Y	Y	
27	CRESOL (MIXED ISOMERS)	1319773	Y	Y	Y	Y
28	HYDROGEN FLUORIDE	7664393	Y	Y	Y	Y
29	O-XYLENE	95476	Y	Y	Y	Y
30	NAPHTHALENE	91203	Y	Y	Y	Y
31	NICKEL	7440020	Y	Y	Y	Y
32	CHLORINE	7782505	Y	Y		Y
33	LEAD	7439921	Y	Y	Y	Y
34	METHYL ISOBUTYL KETONE	108101	Y	Y		
35	ETHYLENE GLYCOL	107211	Y	Y	Y	Y
36	MOLYBDENUM TRIOXIDE	1313275	Y	Y	Y	Y
37	ZINC	7440666	Y	Y	Y	Y
38	HYDROCHLORIC ACID	7647010	Y	Y		Y
39	GLYCOL ETHERS	79141	Y	Y	Y	Y
40	BARIUM	7440393	Y	Y	Y	Y
41	COPPER	7440508	Y	Y	Y	Y
42	1,1,1-TRICHLOROETHANE	71556	Y	Y	Y	Y
43	ANTIMONY	7440360	Y	Y	Y	Y
44	1,3-BUTADIENE	106990	Y	Y		Y
45	N-BUTYL ALCOHOL	71363	Y			
46	FORMALDEHYDE	50000	Y	Y	Y	Y
47	EPICHLOROHYDRIN	106898	Y		Y	
48	COBALT	7440484	Y	Y	Y	Y

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[a] Rank = Order of Frequency of Occurrence
[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 7 : PETROLEUM REFINING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
49	VANADIUM (FUME OR DUST)	7440622	Y		Y	Y
50	CUMENE HYDROPEROXIDE	80159	Y			
51	TERT-BUTYL ALCOHOL	75650	Y		Y	
52	4,4'-ISOPROPYLIDENEDIPHENOL	80057	Y		Y	
53	BUTYRALDEHYDE	123728	Y			
54	BIPHENYL	92524	Y	Y	Y	Y
55	CARBON TETRACHLORIDE	56235	Y	Y	Y	Y
56	STYRENE	100425	Y	Y	Y	Y
57	TRICHLOROETHYLENE	79016	Y	Y		
58	MANGANESE	7439965	Y	Y		Y
59	ETHYLENE OXIDE	75218	Y			
60	AMMONIUM NITRATE (SOLUTION)	6484522		Y		
61	CARBON DISULFIDE	75150	Y	Y		
62	1,2-DICHLOROETHANE	107062	Y	Y	Y	Y
63	POLYCHLORINATED BIPHENYLS	1336363				Y
64	PHOSPHORUS (YELLOW OR WHITE)	7723140				Y
64	PHOSPHORUS (YELLOW OR WHITE)	7723140				Y
65	QUINOLINE	91225	Y			
66	2-METHOXYETHANOL	109864	Y		Y	Y
67	1,2-DIBROMOETHANE	106934	Y	Y	Y	Y
68	TETRACHLOROETHYLENE	127184	Y	Y	Y	
69	ANTHRACENE	120127	Y	Y	Y	
70	2,4-DIMETHYLPHENOL	105679		Y	Y	
71	HYDROGEN CYANIDE	74908	Y	Y		
72	CHLOROMETHANE	74873	Y			
73	NITROBENZENE	98953		Y		
74	1,2-DICHLOROPROPANE	78875	Y	Y	Y	
75	CARBONYL SULFIDE	463581	Y	Y		
76	ACETONITRILE	75058	Y			
77	SILVER	7440224	Y	Y		Y
78	2-ETHOXYETHANOL	110805	Y			
79	THALLIUM	7440280		Y		Y
80	FREON 113	76131	Y			
81	SELENIUM	7782492	Y	Y	Y	Y
82	DICHLOROMETHANE	75092	Y			
83	MERCURY	7439976		Y	Y	Y
84	CADMIUM	7440439		Y	Y	Y
85	1,1,2-TRICHLOROETHANE	79005	Y	Y		
86	ARSENIC	7440382	Y	Y	Y	Y
87	CYANIDE COMPOUNDS	57125				Y
88	CHLORINE DIOXIDE	10049044	Y			
89	ACRYLIC ACID	79107	Y			
90	1,3-DICHLOROPROPYLENE	542756	Y			
91	1,2-BUTYLENE OXIDE	106887	Y			
92	CHLOROBENZENE	108907				Y
93	1,4-DIOXANE	123911	Y			
94	DI(2-ETHYLHEXYL) PHTHALATE (DEHP)	117817			Y	
95	BERYLLIUM	7440417	Y			
96	CHLOROFORM	67663				Y

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[a] Rank = Order of Frequency of Occurrence
[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

APPENDIX III

LISTING OF ANALYTES, METHODS, AND DETECTION OR QUANTITATION LIMITS FOR POLLUTANTS OF CONCERN TO RISK ASSESSMENT

The purpose of this appendix is to familiarize the reader with the variety of EPA methods that are available for analysis of pollutants of concern in risk assessment. The appendix facilitates appropriate method selection for pollutants in the matrix of interest.

Appendix III consists first of a glossary of method abbreviations and definitions. Tables I, II, and III depict detection limit estimates achievable for 32 organic and inorganic pollutants of potential concern to risk assessment in air soil, air and water matrices respectively.

Table IV provides a methods summary of each method of analysis for these pollutants. The 32 pollutants listed were chosen because they have reported cancer risk, and occur at a frequency of greater than 2% in 141 National Priorities List (NPL) sites[1].

Tables V-A and V-B provide an additional comparison of analytical methodologies for selected organic compound classes and organics analytes including method detection ranges and the applicable analytical system and preparation procedures.

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[1] Source: CLP Statistical Datebase (STAT)

APPENDIX III
TABLE I
METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AIR MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
ORGANOCHLORINE PESTICIDES/AROCLORS				
50293	pp'-DDT	EPA AIR METHOD TO-4 "Method for the Determination of Organochlorine Pesticides and Polychlorinated Biphenyls in Ambient Air"	GC/EC	EDL = >1 ng/m3
57749	Chlordane	EPA AIR METHOD TO-4 "Method for the Determination of Organochlorine Pesticides and Polychlorinated Biphenyls in Ambient Air"	GC/EC	EDL = >1 ng/m3
72559	pp'-DDE	EPA AIR METHOD TO-4 "Method for the Determination of Organochlorine Pesticides and Polychlorinated Biphenyls in Ambient Air"	GC/EC	EDL = >1 ng/m3

APPENDIX III
TABLE I
METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AIR MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
VOLATILE COMPOUNDS				
100425	Ethenyl Benzene (Styrene)	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = .01 ng/ul
106467	1,4-dichlorobenzene	EPA AIR METHOD TO-1 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Tenax Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	GC/MS	NA
		EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	NA
		EPA AIR METHOD TO-3 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"	GC/FID	NA
107062	1,2-dichloroethane	EPA AIR METHOD TO-2 "Method for the Determination of Volatile Organic Compounds in Ambient Air by Carbon Molecular Sieve Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	GC/MS	MDL = 37 ng/l
		EPA AIR METHOD TO-3 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"	GC/FID	MDL = 44 ppb
127184	Tetrachloroethene (Tetrachloroethylene)	EPA AIR METHOD TO-1 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Tenax Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	GC/MS	NA

APPENDIX III
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METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AIR MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
127184	Tetrachloroethene (Tetrachloroethylene)	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = .05 ng/ul
		EPA AIR METHOD TO-3 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"	GC/FID	MDL = 69 ppb
56235	Tetrachloromethane (Carbon Tetrachloride)	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = 2 ng/ul
		EPA AIR METHOD TO-2 "Method for the Determination of Volatile Organic Compounds in Ambient Air by Carbon Molecular Sieve Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	GC/MS	MDL = 86 ng/l
		EPA AIR METHOD TO-3 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"	GC/FID	NA
67663	Trichloromethane (Chloroform)	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = 2 ng/ul
		EPA AIR METHOD TO-2 "Method for the Determination of Volatile Organic Compounds in Ambient Air by Carbon Molecular Sieve Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	GC/MS	MDL = 89 ng/l

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(AIR MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
67663	Trichloromethane (Chloroform)	EPA AIR METHOD TO-3 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"	GC/FID	MDL = 84 ppb
71432	Benzene	EPA AIR METHOD TO-1 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Tenax Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	GC/MS	NA
		EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = .006 ng/ul
		EPA AIR METHOD TO-2 "Method for the Determination of Volatile Organic Compounds in Ambient Air by Carbon Molecular Sieve Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	GC/MS	MDL = 15 ng/l
		EPA AIR METHOD TO-3 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"	GC/FID	MDL = 93 ppb
75014	Chloroethene (Vinyl Chloride)	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = 2.343 ppbv
75092	Dichloromethane (Methylene Chloride)	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = 2.255 ppbv

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
75092	Dichloromethane (Methylene Chloride)	EPA AIR METHOD TO-2 "Method for the Determination of Volatile Organic Compounds in Ambient Air by Carbon Molecular Sieve Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	GC/MS	MDL = 28 ng/l
		EPA AIR METHOD TO-3 "Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"	GC/FID	NA
75343	1,1-dichloroethane	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = 1.273 ppbv
78875	1,2-dichloropropane	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = 2.4 ppbv
79005	1,1,2-trichloroethane	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = 1.891 ppbv
79345	1,1,2,2-tetrachloroethane	EPA AIR METHOD TO-14 "The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	GC/MS	EDL = 1.035 ppbv

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(SOIL/SEDIMENT MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
METALS				
7439921	LEAD	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	FLAME	CRDL = 5 ug/kg
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 5 ug/kg
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 5 ug/kg
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	GFAA	MDL = 5 ug/kg
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	ICP	EDL = 42 ug/kg
		MCAWW METHOD 239.1 "Lead (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = 0.1 ug/kg
		MCAWW METHOD 239.2 "Lead (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/kg
		SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = 42 ug/kg
7439976	MERCURY	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	CVAA	CRDL = 0.2 ug/kg
		MCAWW METHOD 245.5 "Mercury in Sediment (Manual Cold Vapor Technique)"	CVAA	MDL = .2 ug/kg

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7439976	MERCURY	SW846 METHOD 7471 "Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)"	CVAA	NA
7440382	ARSENIC	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 10 ug/kg
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 10 ug/kg
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	GFAA	MDL = 10 ug/kg
		MCAWW METHOD 206.2 "Arsenic (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/kg
		SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = 53 ug/kg
		SW846 METHOD 7060 "Arsenic (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/kg
		SW846 METHOD 7061 "Arsenic (Atomic Absorption, Gaseous Hydride)"	HYDAA	MDL = 0.002 ug/kg
7440417	BERYLLIUM	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	FLAME	CRDL = 5 ug/kg
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 5 ug/kg
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 5 ug/kg

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(SOIL/SEDIMENT MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7440417	BERYLLIUM	ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	ICP	EDL = 0.3 ug/kg
		MCAWW METHOD 210.1 "Beryllium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = 0.005 ug/kg
		MCAWW METHOD 210.2 "Beryllium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 0.2 ug/kg
		SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = 0.3 ug/kg
		SW846 METHOD 7090 "Beryllium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = 0.005 ug/kg
		SW846 METHOD 7091 "Beryllium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 0.2 ug/kg
7440439	CADMIUM	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 5 ug/kg
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 5 ug/kg
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	FLAME	CRDL = 5 ug/kg
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	ICP	MDL = 5 ug/kg
		MCAWW METHOD 213.1 "Cadmium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = 0.005 ug/kg

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(SOIL/SEDIMENT MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7440439	CADMIUM	MCAWW METHOD 213.2 "Cadmium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 0.1 ug/kg
		SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = 4 ug/kg
		SW846 METHOD 7130 "Cadmium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = 0.005 ug/kg
		SW846 METHOD 7131 "Cadmium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 0.1 ug/kg
7440473	CHROMIUM	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	FLAME	CRDL = 10 ug/kg
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 10 ug/kg
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 10 ug/kg
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	GFAA	EDL = 7 ug/kg
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	ICP	MDL = 10 ug/kg
		MCAWW METHOD 218.1 "Chromium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = 0.05 ug/kg
		MCAWW METHOD 218.2 "Chromium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/kg

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(SOIL/SEDIMENT MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7440473	CHROMIUM	SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = 7 ug/kg

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
ORGANOCHLORINE PESTICIDES/AROCLORS				
11096825	Aroclor 1260 (PCB-1260)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 160 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 33 ug/kg
50293	pp'-DDT	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 16.0 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 3.3 ug/kg
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	PQL = 8.0 ug/kg
57749	Chlordane	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 80 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 3.3 ug/kg
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	PQL = 9.0 ug/kg
58899	Lindane	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 8.0 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis	GC/EC	CRQL = 3.3 ug/kg

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
		by Quick Turnaround Gas Chromatography Techniques"		
60571	Dieldrin	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 16.0 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 3.3 ug/kg
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	PQL = 10 ug/kg
72559	pp'-DDE	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 16.0 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 3.3 ug/kg
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	PQL = 3.0 ug/kg
76448	Heptachlor	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 8.0 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 3.3 ug/kg
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	PQL = 2.0 ug/kg

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(SOIL/SEDIMENT MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
SEMIVOLATILE COMPOUNDS				
111444	Bis-(2-Dichloroethyl) ether	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 330 ug/kg
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 22 ug/kg
117817	Bis (2-ethylhexyl) phthalate	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 330 ug/kg
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 553 ug/kg
		SW846 METHOD 8060 "Phthalate Esters"	GC/EC	PQL = 228 ug/kg
		SW846 METHOD 8270 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	GC/MS	PQL = 660 ug/kg
50328	Benzo <a> pyrene	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 330 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 670 ug/kg
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 8 ug/kg
		SW846 METHOD 8270 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	GC/MS	PQL = 660 ug/kg

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
50328	Benzo <a> pyrene	SW846 METHOD 8310 "Polynuclear Aromatic Hydrocarbons"	HPLC	PQL = 15 ug/kg
78591	3,5,5-trimethyl-2-cyclohexen-1-one (Isophorone)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 330 ug/kg
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 5 ug/kg
		SW846 METHOD 8270 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	GC/MS	PQL = 660 ug/kg
86306	N-nitrosodiphenylamine	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 330 ug/kg
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 36 ug/kg

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
VOLATILE COMPOUNDS				
100425	Ethenyl Benzene (Styrene)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 17 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
106467	1,4-dichlorobenzene	ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 20 ug/kg
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = 2.4 ug/kg
		SW846 METHOD 8020 "Aromatic Volatile Organics"	GC/PID	PQL = 3.0 ug/kg
		SW846 METHOD 8270 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	GC/MS	PQL = 660 ug/kg
107062	1,2-dichloroethane	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 40 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 3 ug/kg

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
107062	1,2-dichloroethane	SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = .3 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
127184	Tetrachloroethene (Tetrachloroethylene)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 40 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 10 ug/kg
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = .3 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
56235	Tetrachloromethane (Carbon Tetrachloride)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 40 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 9 ug/kg

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
56235	Tetrachloromethane (Carbon Tetrachloride)	SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = 1.2 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
67663	Trichloromethane (Chloroform)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 40 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 2 ug/kg
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = .5 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
71432	Benzene	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 40 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 8 ug/kg

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(SOIL/SEDIMENT MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
71432	Benzene	SW846 METHOD 8020 "Aromatic Volatile Organics"	GC/PID	PQL = 2.0 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
75014	Chloroethene (Vinyl Chloride)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 16 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 40 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 11 ug/kg
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = 1.8 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 10 ug/kg
75092	Dichloromethane (Methylene Chloride)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 280 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
75343	1,1-dichloroethane	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-	GC/MS	CRQL = 5 ug/kg

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TABLE II
METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(SOIL/SEDIMENT MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
		Media, Multi-Concentration"		
75343	1,1-dichloroethane	ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 1 ug/kg
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = .7 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
75354	1,1-dichloroethene	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 40 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 5 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
78875	1,2-dichloropropane	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 5 ug/kg
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = .4 ug/kg

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METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(SOIL/SEDIMENT MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
78875	1,2-dichloropropane	SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
79005	1,1,2-trichloroethane	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 1 ug/kg
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = .2 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg
79345	1,1,2,2-tetrachloroethane	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/kg
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 40 ug/kg
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	MDL = 6 ug/kg
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	PQL = .3 ug/kg
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/kg

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METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
METALS				
7439921	LEAD	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	FLAME	CRDL = 5 ug/l
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 5 ug/l
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 5 ug/l
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	GFAA	MDL = 5 ug/l
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	ICP	EDL = 42 ug/l
		MCAWW METHOD 200.7 "Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes"	ICP	EDL = 42 ug/l
		MCAWW METHOD 239.1 "Lead (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = .1 mg/l
		MCAWW METHOD 239.2 "Lead (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/l
		SMEWW METHOD 3111B "Direct Air-Acetylene Flame Method"	FLAME	EDL = .05 mg/l
		SMEWW METHOD 3111C "Extraction/Air-Acetylene Flame Method"	FLAME	NA

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(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7439921	LEAD	SMEWW METHOD 3113B "Electrothermal Atomic Absorption Spectrometric Method"	GFAA	EDL = 1 ug/l
		SMEWW METHOD 3120B "Inductively Coupled Plasma (ICP) Method"	ICP	EDL = 40 ug/l
		SMEWW METHOD 3500PB D "Dithizone Method"	COLOR	EDL = .1 ug/ml
		SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = 42 ug/l
		SW846 METHOD 7420 "Lead (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = .1 mg/l
		SW846 METHOD 7421 "Lead (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/l
7439976	MERCURY	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	CVAA	CRDL = 0.2 ug/l
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	CVAA	MDL = .2 ug/l
		MCAWW METHOD 245.1 "Mercury (Manual Cold Vapor Technique)"	CVAA	MDL = .2 ug/l
		MCAWW METHOD 245.2 "Mercury (Automated Cold Vapor Technique)"	CVAA	MDL = .2 ug/l
		SMEWW METHOD 3112B "Cold-Vapor Atomic Absorption Spectrometric Method"	CVAA	NA

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METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT (AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7439976	MERCURY	SMEWW METHOD 3500HG C "Dithizone Method"	COLOR	EDL = 2 ug/l
		SW846 METHOD 7470 "Mercury in Liquid Waste (Manual Cold-Vapor Technique)"	CVAA	NA
7440382	ARSENIC	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 10 ug/l
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 10 ug/l
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	ICP	EDL = 53 ug/l
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	GFAA	MDL = 10 ug/l
		MCAWW METHOD 200.7 "Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes"	ICP	EDL = 53 ug/l
		MCAWW METHOD 206.2 "Arsenic (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/l
		MCAWW METHOD 206.3 "Arsenic (Atomic Absorption-Gaseous Hydride)"	HYDAA	MDL = 2 ug/l
		MCAWW METHOD 206.4 "Arsenic (Spectrophotometric-SDDC)"	COLOR	MDL = 10 ug/l
		MCAWW METHOD 206.5 "Arsenic (Sample Digestion prior to Total Arsenic	HYDAA	NA

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(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
		Analysis by Silver Diethyldithiocarbamate or Hydride Procedures)"		
7440382	ARSENIC	SMEWW METHOD 3113B "Electrothermal Atomic Absorption Spectrometric Method"	GFAA	EDL = 1 ug/l
		SMEWW METHOD 3114B "Manual Hydride Generation/Atomic Absorption Spectrometric Method"	HYDAA	EDL = .002 mg/l
		SMEWW METHOD 3120B "Inductively Coupled Plasma (ICP) Method"	ICP	EDL = 50 ug/l
		SMEWW METHOD 3500AS C "Silver Diethyldithiocarbamate Method"	COLOR	EDL = 1 ug
		SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = 53 ug/l
		SW846 METHOD 7060 "Arsenic (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/l
		SW846 METHOD 7061 "Arsenic (Atomic Absorption, Gaseous Hydride)"	HYDAA	MDL = 0.002 mg/l
7440417	BERYLLIUM	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	FLAME	CRDL = 5 ug/l
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 5 ug/l
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 5 ug/l
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic	ICP	MDL = 5 ug/l

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METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
		Emission Spectroscopy and Atomic Absorption Spectroscopy"		
7440417	BERYLLIUM	MCAWW METHOD 200.7 "Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes"	ICP	EDL = .3 ug/l
		MCAWW METHOD 210.1 "Beryllium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = .005 mg/l
		MCAWW METHOD 210.2 "Beryllium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = .2 ug/l
		SMEWW METHOD 3111B "Direct Air-Acetylene Flame Method"	FLAME	EDL = .005 mg/l
		SMEWW METHOD 3111D "Direct Nitrous Oxide-Acetylene Flame Method"	FLAME	NA
		SMEWW METHOD 3111E "Extraction/Nitrous Oxide-Acetylene Flame Method"	FLAME	EDL = 30 ug/l
		SMEWW METHOD 3113B "Electrothermal Atomic Absorption Spectrometric Method"	GFAA	EDL = .2 ug/l
		SMEWW METHOD 3120B "Inductively Coupled Plasma (ICP) Method"	ICP	EDL = .3 ug/l
		SMEWW METHOD 3500BE D "Aluminon Method"	COLOR	EDL = 5 ug/l
		SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = .3 ug/l
		SW846 METHOD 7090 "Beryllium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = .005 mg/l

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(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7440417	BERYLLIUM	SW846 METHOD 7091 "Beryllium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = .2 ug/l
7440439	CADMIUM	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 5 ug/l
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	FLAME	CRDL = 5 ug/l
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 5 ug/l
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	ICP	MDL = 5 ug/l
		MCAWW METHOD 200.7 "Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes"	ICP	EDL = 4 ug/l
		MCAWW METHOD 213.1 "Cadmium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = .005 mg/l
		MCAWW METHOD 213.2 "Cadmium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = .1 ug/l
		SMEWW METHOD 3111B "Direct Air-Acetylene Flame Method"	FLAME	IDL = .002 mg/l
		SMEWW METHOD 3111C "Extraction/Air-Acetylene Flame Method"	FLAME	NA
		SMEWW METHOD 3120B "Inductively Coupled Plasma (ICP) Method"	ICP	EDL = 4 ug/l

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METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7440439	CADMIUM	SMEWW METHOD 3133B	GFAA	EDL = .1 ug/l
		SMEWW METHOD 3500CD D "Dithizone Method"	COLOR	EDL = .5 ug/ml
		SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = 4 ug/l
		SW846 METHOD 7130 "Cadmium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = .005 mg/l
		SW846 METHOD 7131 "Cadmium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = .1 ug/l
7440473	CHROMIUM	CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	ICP	CRDL = 10 ug/l
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	GFAA	CRDL = 10 ug/l
		CLP SOW METHOD INORG "Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	FLAME	CRDL = 10 ug/l
		ITD METHOD 1620 "Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	ICP	MDL = 10 ug/l
		MCAWW METHOD 200.7 "Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes"	ICP	EDL = 7 ug/l
		MCAWW METHOD 218.1 "Chromium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = .05 mg/l

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METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7440473	CHROMIUM	MCAWW METHOD 218.2 "Chromium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/l
		MCAWW METHOD 218.3 "Chromium (Atomic Absorption, Chelation-Extraction)"	HYDAA	MDL = 1 ug/l
		MCAWW METHOD 218.4 "Chromium, Hexavalent (Atomic Absorption, Chelation-Extraction)"	HYDAA	MDL = 10 ug/l
		MCAWW METHOD 218.5 "Chromium, Dissolved Hexavalent (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 5 ug/l
		SMEWW METHOD 3111B "Direct Air-Acetylene Flame Method"	FLAME	EDL = .02 mg/l
		SMEWW METHOD 3111C "Extraction/Air-Acetylene Flame Method"	FLAME	NA
		SMEWW METHOD 3113B "Electrothermal Atomic Absorption Spectrometric Method"	GFAA	EDL = 2 ug/l
		SMEWW METHOD 3120B "Inductively Coupled Plasma (ICP) Method"	ICP	EDL = 7 ug/l
		SMEWW METHOD 3500CR D "Colorimetric Method"	COLOR	NA
		SW846 METHOD 6010 "Inductively Coupled Plasma Atomic Emission Spectroscopy"	ICP	EDL = 7 ug/l
		SW846 METHOD 7190 "Chromium (Atomic Absorption, Direct Aspiration)"	FLAME	MDL = .05 mg/l
		SW846 METHOD 7191 "Chromium (Atomic Absorption, Furnace Technique)"	GFAA	MDL = 1 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
7440473	CHROMIUM	SW846 METHOD 7195 "Chromium, Hexavalent (Coprecipitation)"	FLAME	NA
		SW846 METHOD 7196 "Chromium, Hexavalent (Colorimetric)"	GFAA	NA
		SW846 METHOD 7197 "Chromium, Hexavalent (Chelation/Extraction)"	FLAME	NA
		SW846 METHOD 7198 "Chromium, Hexavalent (Differential Pulse Polarography)"	GFAA	NA

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
ORGANOCHLORINE PESTICIDES/AROCLORS				
11096825	Aroclor 1260 (PCB-1260)	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/EC	CRQL = .20 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 1.0 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 1 ug/l
		EPA METHOD 608 "Organochlorine Pesticides and PCBs"	GC/EC	NA
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	NA
		EPA DW METHOD 505 "Analysis of Organohalide Pesticides and Aroclors in Water by Microextraction and Chromatography"	GC/EC	MDL = .189 ug/l
		EPA DW METHOD 508 "Determination of Chlorinated Pesticides in Water by Gas Chromatography with an Electron Capture Detector"	GC/EC	NA
		ITD METHOD 1618 "Organo-Halide Pesticides, Organo-Phosphorus Pesticides, and Phenoxy-Acid Herbicides by Wide Bore Capillary Column Gas Chromatography with Selective Detectors"	GC/HSD	MDL = 140 ng/l
		SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	NA

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
11096825	Aroclor 1260 (PCB-1260)	SMEWW METHOD 6630B "Liquid-Liquid Extraction Gas Chromatographic Method I"	GC/MS	NA
		SMEWW METHOD 6630C "Liquid-Liquid Extraction Gas Chromatographic Method II"	GC/EC	NA
50293	pp'-DDT	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/EC	CRQL = .02 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 0.10 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 0.1 ug/l
		EPA METHOD 608 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .012 ug/l
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 4.7 ug/l
		EPA DW METHOD 508 "Determination of Chlorinated Pesticides in Water by Gas Chromatography with an Electron Capture Detector"	GC/EC	EDL = .06 ug/l
		ITD METHOD 1618 "Organo-Halide Pesticides, Organo-Phosphorus Pesticides, and Phenoxy-Acid Herbicides by Wide Bore Capillary Column Gas Chromatography with Selective Detectors"	GC/HSD	MDL = .012 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
50293	pp'-DDT	SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 4.7 ug/l
		SMEWW METHOD 6630B "Liquid-Liquid Extraction Gas Chromatographic Method I"	GC/MS	MDL = 0.012 ug/l
		SMEWW METHOD 6630C "Liquid-Liquid Extraction Gas Chromatographic Method II"	GC/EC	MDL = .012 ug/l
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .012 ug/l
57749	Chlordane	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/EC	CRQL = 0.01 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/ED	CRQL = 0.5 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 0.1 ug/l
		EPA METHOD 608 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .014 ug/l
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	NA
		EPA DW METHOD 505 "Analysis of Organohalide Pesticides and Aroclors in Water by Microextraction and Chromatography"	GC/EC	MDL = .14 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
57749	Chlordane	EPA DW METHOD 508 "Determination of Chlorinated Pesticides in Water by Gas Chromatography with an Electron Capture Detector"	GC/EC	NA
		ITD METHOD 1618 "Organo-Halide Pesticides, Organo-Phosphorus Pesticides, and Phenoxy-Acid Herbicides by Wide Bore Capillary Column Gas Chromatography with Selective Detectors"	GC/HSD	NA
		SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	NA
		SMEWW METHOD 6630B "Liquid-Liquid Extraction Gas Chromatographic Method I"	GC/MS	MDL = 0.014 ug/l
		SMEWW METHOD 6630C "Liquid-Liquid Extraction Gas Chromatographic Method II"	GC/EC	MDL = .014 ug/l
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .014 ug/l
58899	Lindane	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/EC	CRQL = .01 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 0.05 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 0.1 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
58899	Lindane	EPA METHOD 608 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = 0.009 ug/l
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 3.1 ug/l
		EPA DW METHOD 505 "Analysis of Organohalide Pesticides and Aroclors in Water by Microextraction and Chromatography"	GC/EC	MDL = .003 ug/l
		EPA DW METHOD 508 "Determination of Chlorinated Pesticides in Water by Gas Chromatography with an Electron Capture Detector"	GC/EC	EDL = .025 ug/l
		EPA DW METHOD 525 "Determination of Organic Compounds in Drinking Water by Liquid-Solid Extraction and Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .1 ug/l
		ITD METHOD 1618 "Organo-Halide Pesticides, Organo-Phosphorus Pesticides, and Phenoxy-Acid Herbicides by Wide Bore Capillary Column Gas Chromatography with Selective Detectors"	GC/HSD	MDL = 11 ng/l
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .003 ug/l
60571	Dieldrin	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/EC	CRQL = .02 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 0.10 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media,	GC/EC	CRQL = 0.1 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
		Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"		
60571	Dieldrin	EPA METHOD 608 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .002 ug/l
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 2.5 ug/l
		EPA DW METHOD 505 "Analysis of Organohalide Pesticides and Aroclors in Water by Microextraction and Chromatography"	GC/EC	MDL = .012 ug/l
		EPA DW METHOD 508 "Determination of Chlorinated Pesticides in Water by Gas Chromatography with an Electron Capture Detector"	GC/EC	EDL = .02 ug/l
		ITD METHOD 1618 "Organo-Halide Pesticides, Organo-Phosphorus Pesticides, and Phenoxy-Acid Herbicides by Wide Bore Capillary Column Gas Chromatography with Selective Detectors"	GC/HSD	MDL = 6 ng/l
		SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 2.5 ug/l
		SMEWW METHOD 6630B "Liquid-Liquid Extraction Gas Chromatographic Method I"	GC/MS	MDL = 0.002 ug/l
		SMEWW METHOD 6630C "Liquid-Liquid Extraction Gas Chromatographic Method II"	GC/EC	MDL = .002 ug/l
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .002 ug/l
72559	pp'-DDE	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic	GC/EC	CRQL = .02 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
		Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"		
72559	pp'-DDE	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 0.10 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 0.1 ug/l
		EPA METHOD 608 "Organochlorine Pesticides and PCBs"	GC/ED	MDL = .004 ug/l
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 5.6 ug/l
		EPA DW METHOD 508 "Determination of Chlorinated Pesticides in Water by Gas Chromatography with an Electron Capture Detector"	GC/EC	EDL = .01 ug/l
		ITD METHOD 1618 "Organo-Halide Pesticides, Organo-Phosphorus Pesticides, and Phenoxy-Acid Herbicides by Wide Bore Capillary Column Gas Chromatography with Selective Detectors"	GC/HSD	MDL = 10 ng/l
		SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 5.6 ug/l
		SMEWW METHOD 6630B "Liquid-Liquid Extraction Gas Chromatographic Method I"	GC/MS	MDL = 0.004 ug/l
		SMEWW METHOD 6630C "Liquid-Liquid Extraction Gas Chromatographic Method II"	GC/EC	MDL = .004 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
72559	pp'-DDE	SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .004 ug/l
76448	Heptachlor	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/EC	CRQL = .01 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/EC	CRQL = 0.05 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 0.1 ug/l
		EPA METHOD 608 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .003 ug/l
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 1.9 ug/l
		EPA DW METHOD 505 "Analysis of Organohalide Pesticides and Aroclors in Water by Microextraction and Chromatography"	GC/EC	MDL = .003 ug/l
		EPA DW METHOD 508 "Determination of Chlorinated Pesticides in Water by Gas Chromatography with an Electron Capture Detector"	GC/EC	EDL = .01 ug/l
		EPA DW METHOD 525 "Determination of Organic Compounds in Drinking Water by Liquid-Solid Extraction and Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .04 ug/l
		ITD METHOD 1618 "Organo-Halide Pesticides, Organo-Phosphorus Pesticides, and Phenoxy-Acid Herbicides by Wide	GC/HSD	MDL = 5 ng/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
		Bore Capillary Column Gas Chromatography with Selective Detectors"		
76448	Heptachlor	SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 1.9 ug/l
		SMEWW METHOD 6630B "Liquid-Liquid Extraction Gas Chromatographic Method I"	GC/MS	MDL = 0.003 ug/l
		SMEWW METHOD 6630C "Liquid-Liquid Extraction Gas Chromatographic Method II"	GC/EC	MDL = .003 ug/l
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .003 ug/l
		SW846 METHOD 8080 "Organochlorine Pesticides and PCBs"	GC/EC	MDL = .003 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
SEMIVOLATILE COMPOUNDS				
111444	Bis-(2-Dichloroethyl) ether	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 5 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 10 ug/l
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 5.7 ug/l
		SMEWW METHOD 6040B "Closed-Loop Stripping, Gas-Chromatographic/Mass-Spectrometric Analysis"	GC/MC	EDL = 1 ng/l
		SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 5.7 ug/l
		SW846 METHOD 8250 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Packed Column Technique"	GC/MS	MDL = 5.3 ug/l
117817	Bis (2-ethylhexyl) phthalate	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 5 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 10 ug/l
		EPA METHOD 606 "Phthalate Ester"	GC/EC	MDL = 2.0 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
117817	Bis (2-ethylhexyl) phthalate	EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 2.5 ug/l
		EPA DW METHOD 525 "Determination of Organic Compounds in Drinking Water by Liquid-Solid Extraction and Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .6 ug/l
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	ML = 10 ug/l
		SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 2.5 ug/l
		SW846 METHOD 8060 "Phthalate Esters"	GC/EC	MDL = 15 ug/l
		SW846 METHOD 8270 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	GC/MS	PQL = 10 ug/l
50328	Benzo <a> pyrene	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 5 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 16 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 20 ug/l
		EPA METHOD 610 "Polynuclear Aromatic Hydrocarbons"	GC/FID	MDL = .023 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
50328	Benzo <a> pyrene	EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 2.5 ug/l
		EPA DW METHOD 525 "Determination of Organic Compounds in Drinking Water by Liquid-Solid Extraction and Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .04 ug/l
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	ML = 10 ug/ml
		SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 2.5 ug/l
		SMEWW METHOD 6440B "Liquid-Liquid Extraction Chromatographic Method"	GC/MS	MDL = 0.023 ug/l
		SW846 METHOD 8100 "Polynuclear Aromatic Hydrocarbons"	GC/FID	NA
		SW846 METHOD 8270 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	GC/MS	PQL = 10 ug/l
		SW846 METHOD 8270 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	GC/MS	PQL = 10 ug/l
		SW846 METHOD 8310 "Polynuclear Aromatic Hydrocarbons"	HPLC	MDL = .023 ug/l
78591	3,5,5-trimethyl-2-cyclohexen-1-one (Isophorone)	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 5 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
78591	3,5,5-trimethyl-2-cyclohexen-1-one (Isophorone)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 10 ug/l
		EPA METHOD 609 "Nitroaromatics and Isphorone"	GC/EC	MDL = 15.7 ug/l
		EPA METHOD 609 "Nitroaromatics and Isphorone"	GC/FID	MDL = 5.7 ug/l
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 2.2 ug/l
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	ML = 10 ug/l
		SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 2.2 ug/l
		SW846 METHOD 8270 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	GC/MS	PQL = 10 ug/l
86306	N-nitrosodiphenylamine	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 5 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 10 ug/l
		EPA METHOD 607 "Nitrosamines"	GC/HSD	MDL = 0.81 ug/l
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 1.9 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
86306	N-nitrosodiphenylamine	ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	ML = 20 ug/ml

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
VOLATILE COMPOUNDS				
100425	Ethenyl Benzene (Styrene)	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		EPA METHOD 602 "Purgeable Aromatics"	GC/PID	MDL = 0.20 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	MDL = .10 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	NA
		EPA DW METHOD 503.1 "Volatile Aromatic and Unsaturated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/PID	MDL = .008 ug/l
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .2 ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .04 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
100425	Ethenyl Benzene (Styrene)	ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	ML = 10 ug/ml
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 1.06 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l
106467	1,4-dichlorobenzene	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	MDL = .24 ug/l
		EPA METHOD 602 "Purgeable Aromatics"	GC/PID	MDL = .3 ug/l
		EPA METHOD 612 "Chlorinated Hydrocarbons"	GC/ED	MDL = 1.34 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	NA
		EPA METHOD 625 "Base/Neutrals and Acids"	GC/MS	MDL = 4.4 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	NA
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with	GC/PID	MDL = .03 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
		Photoionization and Electrolytic Conductivity Detectors in Series"		
106467	1,4-dichlorobenzene	EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .04 ug/l
		EPA DW METHOD 503.1 "Volatile Aromatic and Unsaturated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/PID	MDL = .02 ug/l
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = 2. ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .03 ug/l
		ITD METHOD 1625 "Semivolatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	ML = 20 ug/ml
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	NA
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 5.27 ug/l
		SMEWW METHOD 6220B "Purge and Trap Gas Chromatographic Method I"	GC/PID	MDL = .3 ug/l
		SMEWW METHOD 6220C	GC/MS	MDL = 0.3 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
106467	1,4-dichlorobenzene	SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .24 ug/l
		SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.24 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.24 ug/l
		SMEWW METHOD 6410B "Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 4.4 ug/l
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .24 ug/l
		SW846 METHOD 8020 "Aromatic Volatile Organics"	GC/PID	MDL = .3 ug/l
		SW846 METHOD 8270 "Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	GC/MS	PQL = 10 ug/l
107062	1,2-dichloroethane	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 20 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
107062	1,2-dichloroethane	EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	MDL = .03 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 2.8 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	MDL = .002 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .03 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	NA
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .2 ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .06 ug/l
		SMEWW METHOD 6210	GC/MS	MDL = 0.97 ug/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 2.8 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .03 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
107062	1,2-dichloroethane	SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.03 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.03 ug/l
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .03 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l
127184	Tetrachloroethene (Tetrachloroethylene)	CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 20 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	MDL = .03 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 4.1 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	MDL = .001 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	MDL = .04 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
127184	Tetrachloroethene (Tetrachloroethylene)	EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .02 ug/l
		EPA DW METHOD 503.1 "Volatile Aromatic and Unsaturated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/PID	MDL = .01 ug/l
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .3 ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .14 ug/l
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	ML = 10 ug/ml
		SMEWW METHOD 6040B "Closed-Loop Stripping, Gas-Chromatographic/Mass-Spectrometric Analysis"	GC/MC	EDL = 100 ng/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 4.1 ug/l
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 0.93 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .03 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
127184	Tetrachloroethene (Tetrachloroethylene)	SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.03 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.03 ug/l
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .03 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l
56235	Tetrachloromethane (Carbon Tetrachloride)	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 20 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	MDL = .12 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 2.8 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	MDL = .003 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
56235	Tetrachloromethane (Carbon Tetrachloride)	EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .02 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	NA
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .3 ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .21 ug/l
		ITD METHOD 1624 "Volatile Organic Compounds by Isotope Dilution GCMS"	GC/MS	ML = 10 ug/ml
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 2.8 ug/l
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 0.88 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .12 ug/l
		SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.12 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
56235	Tetrachloromethane (Carbon Tetrachloride)	SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.12 ug/l
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .12 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l
67663	Trichloromethane (Chloroform)	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/k
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 20 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	MDL = .05 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 1.6 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	NA
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .01 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
67663	Trichloromethane (Chloroform)	EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	NA
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .2 ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .03 ug/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 1.6 ug/l
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 1.03 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .05 ug/l
		SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.05 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.05 ug/l
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .05 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
71432	Benzene	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 20 ug/lg
		EPA METHOD 602 "Purgeable Aromatics"	GC/PID	MDL = .2 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 4.4 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	NA
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	MDL = .01 ug/l
		EPA DW METHOD 503.1 "Volatile Aromatic and Unsaturated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/PID	MDL = .02 ug/l
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .1 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
71432	Benzene	EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .04 ug/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 4.4 ug/l
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 0.97 ug/l
		SMEWW METHOD 6220B "Purge and Trap Gas Chromatographic Method I"	GC/PID	MDL = .2 ug/l
		SMEWW METHOD 6220C "Purge and Trap Gas Chromatographic Method II"	GC/MS	MDL = 0.2 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.18 ug/l
		SW846 METHOD 8020 "Aromatic Volatile Organics"	GC/PID	MDL = .2 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l
75014	Chloroethene (Vinyl Chloride)	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 10 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
75014	Chloroethene (Vinyl Chloride)	CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 20 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	NA
		EPA METHOD 624 "Purgeables"	GC/MS	NA
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	MDL = .01 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .18 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	MDL = .01 ug/l
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .3 ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .17 ug/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	NA

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
75014	Chloroethene (Vinyl Chloride)	SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 0.98 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .18 ug/l
		SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.18 ug/l
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .18 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 10 ug/l
75092	Dichloromethane (Methylene Chloride)	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 2 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	NA
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 2.8 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	NA

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
75092	Dichloromethane (Methylene Chloride)	EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	NA
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .01 ug/l
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = 1. ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .03 ug/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 2.8 ug/l
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 0.99 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .25 ug/l
		SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.25 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.25 ug/l

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(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
75092	Dichloromethane (Methylene Chloride)	SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l
75343	1,1-dichloroethane	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	NA
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 4.7 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	MDL = .003 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .03 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	NA
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .2 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
75343	1,1-dichloroethane	EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .04 ug/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 4.7 ug/l
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 1.05 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .07 ug/l
		SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.07 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.07 ug/l
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .07 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l
75354	1,1-dichloroethene	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
75354	1,1-dichloroethene	CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 20 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 2.8 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	MDL = .003 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	MDL = .10 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .04 ug/l
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .2 ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .12 ug/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 2.8 ug/l
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 1.09 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
75354	1,1-dichloroethene	SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .13 ug/l
		SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.13 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.13 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l
78875	1,2-dichloropropane	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	MDL = .04 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 6.0 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water	GC/HSD	NA

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
		by Purge and Trap Gas Chromatography"		
78875	1,2-dichloropropane	EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .03 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	NA
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .2 ug/l
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .04 ug/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 6.0 ug/l
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 1.01 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .04 ug/l
		SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.04 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.04 ug/l

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CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
78875	1,2-dichloropropane	SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .04 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l
79005	1,1,2-trichloroethane	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	MDL = .02 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 5 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	MDL = .007 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .04 ug/l

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TABLE III
METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
79005	1,1,2-trichloroethane	EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	NA
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	NA
		EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .10 ug/l
		SMEWW METHOD 6040B "Closed-Loop Stripping, Gas-Chromatographic/Mass-Spectrometric Analysis"	GC/MS	EDL = 2 ng/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 5.0 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .02 ug/l
		SMEWW METHOD 6230C "Purge and Trap Packed-Column Gas Chromatographic Method II"	GC/MS	MDL = 0.02 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.02 ug/l
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .02 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l

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METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
79345	1,1,2,2-tetrachloroethane	CLP SOW METHOD LC-ORG "Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	GC/MS	CRQL = 1 ug/l
		CLP SOW METHOD ORG "Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	GC/MS	CRQL = 5 ug/l
		CLP SOW METHOD QTM "Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	GC/EC	CRQL = 20 ug/l
		EPA METHOD 601 "Purgeable Halocarbons"	GC/HSD	MDL = .03 ug/l
		EPA METHOD 624 "Purgeables"	GC/MS	MDL = 6.9 ug/l
		EPA DW METHOD 502.1 "Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	GC/HSD	MDL = .01 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/HSD	MDL = .02 ug/l
		EPA DW METHOD 502.2 "Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	GC/PID	NA
		EPA DW METHOD 524.1 "Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .4 ug/l

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METHODS AND DETECTION/QUANTITATION LIMITS FOR SPECIFIED ANALYTES OF CONCERN TO RISK ASSESSMENT
(AQUEOUS MATRICES)

CAS NUMBER	ANALYTE/COMMON NAME	METHOD REFERENCE/ TITLE OF METHOD	INSTRUMENTATION	QUANTITATION/ DETECTION LIMIT
79345	1,1,2,2-tetrachloroethane	EPA DW METHOD 524.2 "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	GC/MS	MDL = .04 ug/l
		SMEWW METHOD 6040B "Closed-Loop Stripping, Gas-Chromatographic/Mass-Spectrometric Analysis"	GC/MS	EDL = 50 ng/l
		SMEWW METHOD 6210B "Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	GC/MS	MDL = 6.9 ug/l
		SMEWW METHOD 6210D "Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	GC/MS	MDL = 1.11 ug/l
		SMEWW METHOD 6230B "Purge and Trap Packed-Column Gas Chromatographic Method I"	GC/HSD	MDL = .03 ug/l
		SMEWW METHOD 6230D "Purge and Trap Capillary-Column Gas Chromatographic Method"	GC/PID	MDL = 0.03 ug/l
		SW846 METHOD 8010 "Halogenated Volatile Organics"	GC/HSD	MDL = .03 ug/l
		SW846 METHOD 8240 "Gas Chromatography/Mass Spectrometry for Volatile Organics"	GC/MS	PQL = 5 ug/l

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
CLP SOW		
METHOD INORG	"Statement of Work for Inorganics Analysis - Mulit-Media, Multi-Concentration"	This method is for the analysis of 23 metals and cyanide. Sample matrices compatible with this method include waters and soil/sediments. Minimum sample volume required for analysis is 1 liter for aqueous samples and 10 grams for soil/sediments. Samples are prepared using a strong acid digestion. Analysis is performed by ICP, GFAA or FLAME. Mercury analysis is perfomed by CVAA.
METHOD LC-ORG	"Chemical Analytical Services for the Analysis of Low Concentration Water Samples for Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) and Gas Chromatography/Electron Capture (GC/EC) Techniques"	This method consists of three separate methods. These methods are for the analysis of 40 volatile compounds, 60 semivolatile compounds and 28 organochlorine pesticides and aroclors. Sample matrices compatible with this method include drinking water, surface water and ground water. Minimum volume required for volatile analysis is 25 ml. Semivolatiles and pesticides require 1 liter each. Samples for volatile analysis are prepared using a purge and trap technique. Analysis is performed by GC/MS. Semivolatiles and pesticides are prepared using various extraction techniques. Semivolatile analysis is performed by GC/MS and pesticide analysis by GC/EC.
METHOD ORG	"Statement of Work for Organics Analysis - Multi-Media, Multi-Concentration"	This method consists of three separate methods. These methods are for the analysis of 34 volatile compounds, 65 semivolatile compounds and 27 organochlorine pesticides and aroclors. Sample matrices compatible with these methods include waters and soil/sediments. Minimum sample volumes required for volatile analysis is 5 ml for waters and 5 grams for soil. Semivolatiles and pesticides require 1 liter each for water samples and 30 grams for soils. Samples for volatile analysis are prepared using a purge and trap technique. Analysis is performed by GC/MS. Samples for semivolatile and pesticides analyses are prepared using various extraction techniques. Analysis for semivolatiles is performed by GC/MS. Analysis for pesticides is performed by GC/EC. A confirmatory analysis may be performed for pesticides using a second column or GC/MS.
METHOD QTM	"Chemical Analytical Services for Multi-Media, Multi-Concentration Samples for Organic Analysis by Quick Turnaround Gas Chromatography Techniques"	This method consists of five separate methods. These methods are for the analysis of 21 volatile compounds, 16 polynuclear aromatic hydrocarbons, 16 phenols, 19 pesticides and 8 aroclors plus toxaphene. Sample matrices compatible with this method include water and soil/sediments. Minimum sample volume is dependent upon the analysis desired. Samples are prepared using a solid phase extraction technique. Analysis is performed using GC. Type of detector is dependent upon the analysis desired.

CLP SOW CONTRACT LABORATORY PROGRAM (CLP) STATEMENT OF WORK, , OFFICE OF EMERGENCY AND REMEDIAL RESPONSE

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METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
EPA		
METHOD 601	"Purgeable Halocarbons"	This method is for the analysis of 29 purgeable halocarbons. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 25 ml. Samples are prepared by purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed by GC/HSD. A confirmatory analysis may be performed using a second column or GC/MS.
METHOD 602	"Purgeable Aromatics"	This method is for the analysis of 7 purgeable aromatic compounds. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 10 ml. Samples are prepared by purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed by GC/PID. A confirmatory analysis may be performed by using a second column or GC/MS.
METHOD 606	"Phthalate Ester"	This method is for the analysis of 6 phthalate ester compounds. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 1 liter. Samples are prepared using a separatory funnel extraction. Analysis is performed by GC/EC. A confirmatory analysis may be performed using a second column or GC/MS.
METHOD 607	"Nitrosamines"	This method is for the analysis of 3 nitrosamines. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 1 liter. Samples are prepared by methylene chloride extraction through a separatory funnel. The extract is concentrated and exchanged to methanol. Analysis is performed using GC/NPD. A confirmatory analysis may be done using a second dissimilar column or GC/MS.
METHOD 608	"Organochlorine Pesticides and PCBs"	This method is for the analysis of 25 organochlorine pesticides and aroclors. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 1 liter. Samples are prepared by using a separatory funnel extraction. Analysis is performed by GC/EC. A confirmatory analysis may be performed using a second column or GC/MS.
METHOD 609	"Nitroaromatics and Isphorone"	This method is for the analysis of 4 nitroaromatics and isophorone. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 1 liter. Samples are prepared using a separatory funnel extraction. Analysis is

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METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
EPA		
		performed by eithed GC/EC or GC/FID. A confirmatory analysis may be performed using a second column or GC/MS.
METHOD 610	"Polynuclear Aromatic Hydrocarbons"	This method is for the analysis of 16 polynuclear aromatic hydrocarbons. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 1 liter. Samples are prepared using a separatory funnel extraction. Analysis is performed by GC/EC. GC/FID may also be used, however, it does not resolve the difference between certain compounds. A confirmatory analysis may be performed using a second column or GC/MS.
METHOD 612	"Chlorinated Hydrocarbons"	This method is for the analysis of 9 chlorinated hydrocarbons. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is liter. Samples are prepared using a separatory funnel extraction. Analysis is performed using GC/EC. A confirmatory analysis may be performed using a second column or GC/MS.
METHOD 624	"Purgeables"	This method is for the analysis of 31 purgeable organic compounds. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 5 ml. Samples are prepared by purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed by GC/MS.
METHOD 625	"Base/Neutrals and Acids"	This method is for the analysis of 81 semivolatile compounds. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 1 liter. Samples are prepared using a separatory funnel extraction or a continuous liquid-liquid extraction. Analysis is performed by GC/MS.

EPA GUIDELINES ESTABLISHING TEST PROCEDURES FOR THE ANALYSIS OF POLLUTANTS UNCER THE CLEAN WATER ACT FINAL RULE AND INTERIM FINAL RULE AND PROPOSED RULE, 10/84, , 40 CFR PART 136

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METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
EPA AIR		
METHOD TO-1	"Method for the Determination of Volatile Organic Compounds in Ambient Air Using Tenax Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	This method is for the analysis of 19 nonpolar volatile compounds with boiling points between 80 and 200 degrees C. Samples are collected on pre-cleaned tenax cartridges. Minimum sample volume required for analysis is highly variable and dependent upon the level of detection desired (Refer to method for sampling techniques, cartridge prepartion and sample volumes). Samples are prepared by heating the tenax cartridge and desorbing the volatile compounds from the cartridge. Analysis is performed by GC/MS.
METHOD TO-14	"The Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis"	This method is for the analysis of 40 volatile organic compounds. Samples are collected on cleaned and certified SUMMA canisters. Minimum sample volume required for this analysis is highly variable and dependent upon the level of detection desired (Refer to method for information on canister preparation and sample collection techniques). Analysis is performed using GC/MS or GC with a multidetector analytical system.
METHOD TO-2	"Method for the Determination of Volatile Organic Compounds in Ambient Air by Carbon Molecular Sieve Adsorption and Gas Chromatography/Mass Spectrometry(GC/MS)"	This method is for the analysis 11 of volatile organic compounds with boiling points between -15 and 120 degrees C. Samples are collected on pre-cleaned carbon molecular sieves. Minimum sample volume required for analysis is highly variable and dependent upon the level of detection desired. Samples are prepared using a heated purge and trap technique. Analysis is performed by GC/MS.
METHOD TO-3	"Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"	This method is for the analysis of 8 volatile organic compounds with boiling points between -10 and 200 degrees C. Minimum sample volume required for analysis is highly variable and is dependent upon the level of detection desired. Samples are prepared using a cryogenic trap technique. Analysis is performed by GC/EC or GC/FID.
METHOD TO-4	"Method for the Determination of Organochlorine Pesticides and Polychlorinated Biphenyls in Ambient Air"	This method is for the analysis of 11 organochlorine pesticides and aroclors. Samples are collected on polyurethane foam filters. Minimum sample volume required for analysis is highly variable and is dependent upon the level of detection desired. Samples are prepared using a soxhlet extraction. Analysis is performed by GC/EC.

EPA AIR   COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR, 5/88, ENVIRONMENTAL MONITORING SYSTEMS LABORATORY/RTP, EPA 600/4-84-041

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METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
EPA DW		
METHOD 502.1	"Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography"	This method is for the analysis of 40 halogenated volatile organic compounds. Sample matrices compatible with this method include drinking water, source water and water being tested for potability. Minimum sample volume required for analysis is 10 ml. Samples are prepared by purging the sample with an inert gas and trapping in a sorbent material. Analysis is performed by GC/HSD. A confirmatory analysis may be performed using a second column or GC/MS.
METHOD 502.2	"Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series"	This method is for the analysis of 60 volatile organic compounds. Sample matrices compatible with this method include drinking water, source water and water being treated for potability. Minimum sample volume for this analysis is 10 ml. Samples are prepared by purging the sample with an inert gas and trapping in a sorbent material. Analysis is performed by GC/PID and GC/HSD. A confirmatory analysis may be performed using two detectors or an alternative GC/MS method.
METHOD 503.1	"Volatile Aromatic and Unsaturated Organic Compounds in Water by Purge and Trap Gas Chromatography"	This method is for the analysis of 28 aromatic and unsaturated organic compounds. Sample matrices compatible with this method include drinking water, source water and water being treated for potability. Minimum volume required for analysis is 10 ml. Samples are prepared by purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed by GC/PID. A confirmatory analysis may be performed using a second column or an alternative GC/MS method.
METHOD 505	"Analysis of Organohalide Pesticides and Aroclors in Water by Microextraction and Chromatography"	This method is for the analysis of 25 organohalide pesticides and aroclors. Sample matrices compatible with this method include drinking water, source water and water being treated for potability. Minimum sample volume required for analysis is 35 ml. Samples are prepared by extraction with hexane and analysis is performed by GC/EC.
METHOD 508	"Determination of Chlorinated Pesticides in Water by Gas Chromatography with an Electron Capture Detector"	This method is for the analysis of 38 chlorinated pesticides and aroclors. Sample matrices compatible with this method include ground water and drinking water. Minimum sample volume for analysis is 1 liter. Samples are prepared by extraction with methylene chloride in a seperatory funnel. The extract is dried and concentrated. Analysis is performed by GC/EC. A confirmatory analysis may be performed using an alternate detector, a second column or GC/MS
METHOD 524.1	"Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass	This method is for the analysis of 48 volatile compounds. Sample matrices compatible with this method include drinking water, source water and water

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METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
EPA DW		
	Spectrometry"	being treated for potability. Minimum sample volume required for analysis is 5 ml, however, 25 ml is recommended to obtain higher sensitivity. Samples are prepared by purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed by GC/MS.
METHOD 524.2	"Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry"	This method is for the analysis of 60 volatile organic compounds. Sample matrices compatible with this method include drinking water, source water and water being tested for potabilty. Minimum sample volume required for this analysis is 25 ml. Samples are prepared by purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed by GC/MS.
METHOD 525	"Determination of Organic Compounds in Drinking Water by Liquid-Solid Extraction and Capillary Column Gas Chromatography/Mass Spectrometry"	This method is for the analysis of 43 organic compounds. Sample matrices compatible with this method include drinking water, source water and water being treated for potability. Minimum sample volume required for analysis is 1 liter. Samples are prepared by passing the sample through a liquid- solid phase extraction cartridge. The organic compounds are eluted off the cartridge using methylene chloride. Analysis is performed by GC/MS.

EPA DW METHODS FOR THE DETERMINATION OF ORGANIC COMPOUNDS IN DRINKING WATER, 12/88, ENVIRONMENTAL MONITORING SYSTEMS LABORATORY/CINN., EPA 600/4-88/039

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METHOD REFERENCE		TITLE OF METHOD	SUMMARY OF METHOD
ITD			
	METHOD 1618	"Organo-Halide Pesticides, Organo-Phosphorus Pesticides, and Phenoxy-Acid Herbicides by Wide Bore Capillary Column Gas Chromatography with Selective Detectors"	This method is for the analysis of 104 pesticides and herbicides. Sample matrices compatible with this method include water soil/sediment and municipal sludges. Minimum sample volume for water samples is 1 liter. Soil and waste sample volumes are dependent on percent solids in the samples. Aqueous samples are prepared using a liquid-liquid extraction technique. Soil samples are prepared using an ultrasonic technique. Analysis is performed by GC. The detector(s) used for the analysis are dependent on the compounds of interest.
	METHOD 1620	"Metals by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectroscopy"	This method is for the analysis of 27 metals. Sample matrices compatible with this method include water and soil/sediment. Minimum sample volume required to perform this analysis is 500 ml for waters and 10 grams for soil/sediments. Samples are prepared using an acid digestion. Analysis for 26 metals is performed by ICP. Five of this metals can alternatively be analyzed using GFAA. Mercury is determined using CVAA.
	METHOD 1624	"Volatile Organic Compounds by Isotope Dilution GCMS"	This method is for the analysis of 57 volatile organic compounds. Sample matrices compatible with this method include water, soil/sediment and wastes. Minimum sample volume required for analysis is 5 ml for aqueous samples and 5 grams for solids. Samples are mixed with labelled analogs and are prepared using a purge and trap technique. Analysis is performed by GC/MS.
	METHOD 1625	"Semivolatile Organic Compounds by Isotope Dilution GCMS"	This method is for the analysis of 57 semivolatile organic compounds. Sample matrice compatible with this method include water, soil and municipal sludge. Minimum sample volume required for analysis is 1 liter for aqueous samples. Sample volumes for soils and wastes are dependent upon the percent solids in the sample. Samples are mixed with labelled analogs and extracted using various extraction techniques. Analysis is performed by GC/MS.

ITD OFFICE OF WATER REGULATIONS AND STANDARDS/INDUSTRIAL TECHNOLOGY DIVISION (ITD) METHODS, 6/89, OFFICE OF WATER,

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METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
MCAWW		
METHOD 200.7	"Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes"	This method is for the analysis of 25 metals. Sample matrices compatible with this method include drinking water, surface water and wastewater. Minimum sample volume required for analysis is 1 liter. Samples are prepared using an acid digestion and analysis is performed by ICP.
METHOD 206.2	"Arsenic (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include drinking water, surface water, saline water, waste, sludge and soil/sediment. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared by digestion with an acid/peroxide solution and analysis is performed by GFAA.
METHOD 206.3	"Arsenic (Atomic Absorption-Gaseous Hydride)"	This method is for the analysis of inorganic arsenic. Sample matrices compatible with this method include drinking water, fresh water and saline water. Minimum sample volume required for analysis is 100 ml. Samples are prepared by the conversion of arsenic to its hydride state. Analysis is performed by HYDAA.
METHOD 206.4	"Arsenic (Spectrophotometric-SDDC)"	This method is for the analysis of inorganic arsenic. Sample matrices compatible with this method include drinking water, surface water, ground water and wastes. Minimum sample volume required for analysis is 100 ml. Samples are prepared by the conversion of arsenic to its hydride state and absorption in a solution of silver diethyldithiocarbamate. Analysis is performed by spectrophotometer.
METHOD 206.5	"Arsenic (Sample Digestion prior to Total Arsenic Analysis by Silver Diethyldithiocarbamate or Hydride Procedures)"	This method is a preparation procedure for the conversion of organic arsenic to inorganic arsenic. Sample matrices compatible with this method include drinking water, surface water and waste. Minimum sample volume required for analysis is dependent upon the concentration of arsenic in the sample. Samples are prpared using a strong acid digestion and are analyzed according to either MCAWW Method 206.3 or 206.4.
METHOD 210.1	"Beryllium (Atomic Absorption, Direct Aspiration)"	Sample matrices compatible with this method include drinking water, surface water, ground water, waste, sludge and soil/sediment. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using a strong acid digestion and are analyzed by FLAME.

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
MCAWW		
METHOD 210.2	"Beryllium (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include drinking water, surface water, ground water, waste, sludge and soil/sediments. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using an acid digestion and are analyzed by GFAA.
METHOD 213.1	"Cadmium (Atomic Absorption, Direct Aspiration)"	Sample matrices compatible with this method include drinking water, surface water, ground water, waste, sludge and soil/sediments. Minimum sample volumes required for analysis are 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using an acid digestion and analyzed by FLAME.
METHOD 213.2	"Cadmium (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include drinking water, surface water, ground water, waste, sludge and soil/sediment. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using an acid digestion and are analyzed by GFAA.
METHOD 218.1	"Chromium (Atomic Absorption, Direct Aspiration)"	Sample matrices compatible with this method include drinking water, surface water, ground water, waste, sludge and soil/sediment. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using an acid digestion and are analyzed by FLAME.
METHOD 218.2	"Chromium (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include drinking water, surface water, ground water, waste, sludge and soil/sediment. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using an acid digestion and analyzed by GFAA.
METHOD 218.3	"Chromium (Atomic Absorption, Chelation-Extraction)"	Sample matrices compatible with this method include drinking water, surface water, ground water and waste. Minimum sample volume required for analysis is 100 ml. Samples are prepared by chelation with ammonium pyrrolidine dithiocarbamate and extracted with methyl isobutyl ketone. Analysis is performed by FLAME.
METHOD 218.4	"Chromium, Hexavalent (Atomic Absorption, Chelation-Extraction)"	Sample matrices compatible with this method include drinking water, surface water, ground water and waste. Minimum sample volume required for analysis

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METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
MCAWW		is 100 ml. Samples are prepared by chelation with ammonium pyrrolidine dithiocarbamate and are extracted with methyl isobutyl ketone. Analysis is performed by GFAA.
METHOD 218.5	"Chromium, Dissolved Hexavalent (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include drinking water surface water and certain filtered wastes. Minimum sample volume required for analysis is 50 ml. Samples are prepared by coprecipitation of lead chromate with lead sulfate in an acetic acid solution. The sample is then chelated/extracted and analysis is performed by GFAA.
METHOD 239.1	"Lead (Atomic Absorption, Direct Aspiration)"	Sample matrices compatible with this method include drinking water, surface water, ground water, waste, sludge and soil/sediment. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using an acid digestion and are analyzed by FLAME.
METHOD 239.2	"Lead (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include drinking water, surface water, ground water, waste, sludge and soil/sediment. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using an acid digestion after which, lanthanum nitrate is added. Analysis is performed by GFAA.
METHOD 245.1	"Mercury (Manual Cold Vapor Technique)"	Sample matrices compatible with this method include drinking water, surface water and saline water. Minimum sample volume required for analysis is 100 ml (Hg conc. > 0.2 ug/l) and 200 ml (Hg conc. < 0.2 ug/l). Samples are prepared by treatment with potassium persulfate. Analysis is performed by CVAA.
METHOD 245.2	"Mercury (Automated Cold Vapor Technique)"	Sample matrices compatible with this method include surface water, waste water and effluent. Minimum sample volume required for analysis is 100 ml. Samples are prepared by treatment with potassium persulfate and analysis is performed by CVAA.
METHOD 245.5	"Mercury in Sediment (Manual Cold Vapor Technique)"	Sample matrices compatible with this method include bottom deposits, sludge and soil/sediment. Minimum sample volume required for analysis is 1 gram. Samples are prepared by digestion in aqua regia following oxidation with

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
MCAWW		potassium permanganate. Analysis is performed by CVAA.

MCAWW METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES, 3/83, ENVIRONMENTAL MONITORING SYSTEMS LABORATORY/CINN., EPA 600/4-79-020

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SMEWW		
METHOD 3111B	"Direct Air-Acetylene Flame Method"	This method is for the analysis of 27 metals. Sample matrices compatible with this method include surface water, ground water and drinking water. Minimum sample volume is dependent on the level of detection desired (Reference SMEWW 3030D). Samples are prepared using a strong acid digestion (Reference SMEWW 3030C through J). Sample analysis is performed by FLAME.
METHOD 3111C	"Extraction/Air-Acetylene Flame Method"	This method is for the analysis of 10 metals a low concentrations. Sample matrices compatible with this method include surface water, ground water and drinking water. Minimum sample volume is dependent on level of detection desired (Reference SMEWW 3030D). Samples are prepared through chelation with ammonium·pyrrolidine dithiocarbamate (APDC) and extracted with methyl isobutyl ketone (MIBK). Analysis is performed by FLAME.
METHOD 3111D	"Direct Nitrous Oxide-Acetylene Flame Method"	This method is for the analysis of 10 metals. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume is dependent on the level of detection required (Reference SMEWW 3030D). Samples are prepared using a strong acid digestion and analyzed by FLAME.
METHOD 3111E	"Extraction/Nitrous Oxide-Acetylene Flame Method"	This method is for the analysis of aluminum and berrylium. Sample matrices compatible with this analysis include ground water, surface water and drinking water. Minimum sample volume is dependent on the level of detection desired (Reference SMEWW 3030D). Samples are prepared via chelation with 8-hydroxyquinoline and are extracted with methyl isobutyl ketone (MIBK). Analysis is performed by FLAME.
METHOD 3112B	"Cold-Vapor Atomic Absorption Spectrometric Method"	This method is for the analysis of mercury. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume for analysis is 100 ml. Samples are prepared using a strong acid digestion and analysis is performed by CVAA.
METHOD 3113B	"Electrothermal Atomic Absorption Spectrometric Method"	This method is for the analysis of 17 metals in micro quantities. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume required for analysis is dependent on the level of detection desired (Reference SMEWW 3030D). Samples are prepared using a strong acid digestion. Analysis is performed

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SMEWW		by GFAA.
METHOD 3114B	"Manual Hydride Generation/Atomic Absorption Spectrometric Method"	This method is for the analysis of arsenic and selenium. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume required for analysis is 50 ml for arsenic and 30 ml for selenium. Samples are prepared by conversion of these metals to their hydride state and analysis is performed by HYDAA.
METHOD 3120B	"Inductively Coupled Plasma (ICP) Method"	This method is for the analysis of 27 metals. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume required for analysis is 100 ml. Samples are prepared using a nitric-hydrochloric acid digestion and analysis is performed by ICP.
METHOD 3500AS C	"Silver Diethyldithiocarbamate Method"	This method is for the analysis of arsenic. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume required for analysis is 25 ml. Samples are prepared by converting arsenic into its hydride state using a zinc and acid solution and treated with silver diethyldithiocarbamate. Analysis is performed by HYDAA.
METHOD 3500BE D	"Aluminon Method"	This method is for the analysis of berrylium. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume required for analysis is 50 ml. Samples are prepared by the addition of an aluminon buffer reagent and analysis is performed by spectrophotometer.
METHOD 3500CD D	"Dithizone Method"	This method is for the analysis of berrylium. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume for analysis is 25 ml. Samples are prepared by treatment with dithizone and extraction with chloroform. Analysis is performed by spectrophotometer.
METHOD 3500CR D	"Colorimetric Method"	This method is for the analysis of chromium. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume for analysis is 100 ml. Samples are prepared through an oxidation reaction and analysis is performed by sprectrophotometer.

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SMEWW		
METHOD 3500HG C	"Dithizone Method"	This method is for the analysis of mercury. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume required for analysis is 500 ml. Samples are prepared by treatment with dithizone and extraction with chloroform. Analysis is performed using a spectrophotometer.
METHOD 3500PB D	"Dithizone Method"	This method is for the analysis of lead. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume for analysis is 100 ml. Samples are prepared by reduction using ammonium citrate cyanide. The sample is then extracted with dithizone in chlorform. Analysis is performed by spectrophotometer.
METHOD 6040B	"Closed-Loop Stripping, Gas-Chromatographic/Mass-Spectrometric Analysis"	This method is for the analysis of volatile organic compounds of intermediate weight. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume required for analysis is 1 liter. Samples are prepared by stipping tthe volatile compounds from using a recirculating stream of air. The volatiles are collected on carbon filters which are then extracted with carbon disulfide. Analysis is performed by GC/MS.
METHOD 6210B	"Purge and Trap Packed-Column Gas Chromatographic/Mass Spectrometric Method I"	This method is for the analysis of 31 volatile organic compounds . Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume for analysis is 10 ml. Samples are prepared by purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed by GC/MS.
METHOD 6210D	"Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method"	This method is for the analysis of 62 purgeable organic compounds. Sample matrices compatible with this method include drinking water, raw source water and water being treated for portability. Minimum sample volume required for analysis is 50ml. Samples are prepared by purging with an inert gas and traping on sorbent material. Analysis is performed using GC/MS.
METHOD 6220B	"Purge and Trap Gas Chromatographic Method I"	This method is for the analysis of 7 aromatic volatile compounds. Sample matrices compatible with this method include ground water, surface water and drinking water. MInimum sample volume required for analysis is 10 ml. Samples are prepared by purging the sample with an inert gas and trapping with a sorbent material. Analysis is performed using GC/PID. A

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METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SMEWW		confirmatory analysis may be performed using a second dissimilar column or GC/MS.
METHOD 6220C	"Purge and Trap Gas Chromatographic Method II"	This method is for the analysis of 27 purgeable aromatic and unsaturated compounds. Sample matrices compatible with this method include drinking water, raw source water, and water being treated for portability. Minimum sample volume for analysis is 50ml. Samples are prepared by purging with an inert gas and trapping on sorbent material. Analysis is performed using GC/PID.
METHOD 6230B	"Purge and Trap Packed-Column Gas Chromatographic Method I"	This method is for the analysis of 29 purgeable halocarbons. Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume for analysis is 50ml. Samples are prepared by purging with an inert gas and trapping on sorbent material. Analysis is performed by GC/HSD. A confirmatory analysis may be performed using a second dissimilar column or GC/MS.
METHOD 6230C	"Purge and Trap Packed-Column Gas Chromatographic Method II"	This method is for the analysis of 42 purgeable halocarbons. Sample matrices compatible with this method include drinking water, raw source water and water being treated for portability. Minimum sample volume required for analysis is 50ml. Samples are prepared by purging with an inert gas and trapping on sorbent material. Analysis is performed using GC/PID.
METHOD 6230D	"Purge and Trap Capillary-Column Gas Chromatographic Method"	This method is for the analysis of 60 purgeable halocarbons. Sample matrices compatible with this method include drinking water, raw source water and water being treated for portability. Minimum sample volume required for analysis is 50 ml. Samples are prepared by purging with an inert gas and trapping on sorbent material. Analysis is performed using a high tempature sensitive GC/PID or GC/HSD.
METHOD 6410B	"Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method"	This method is for the analysis of 81 semivolatile organic compounds. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume required for analysis is 1 liter. Samples are prepared using a methylene chloride extraction and are analyzed using GC/MS.
METHOD 6440B	"Liquid-Liquid Extraction Chromatographic Method"	This method is for the analysis of 16 polynuclear aromatic hydrocarbons (PAH). Sample matrices compatible with this method include municipal and industrial discharges. Minimum sample volume required for analysis is 1

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SMEWW		
		liter.
		Samples are prepared by extraction with methylene chloride and concentration. Analysis is performed using HPLC or GC/FID. A confirmatory analysis may be done using GC/MS.
METHOD 6630B	"Liquid-Liquid Extraction Gas Chromatographic Method I"	This method is for the analysis of 23 organochlorine pesticides. Sample matrices compatible with this method include agricultural discharges. Minimum sample volume required for analysis is 1 liter.
		Samples are prepared by extraction with a mixed solvent and concentration through evaporation. Analysis is performed using GC/EC. A confirmatory analysis may be done using GC/MS.
METHOD 6630C	"Liquid-Liquid Extraction Gas Chromatographic Method II"	This method is for the analysis of 19 organochlorine pesticides. Sample matrices compatible with this method include ground water, surface water and drinking water. Minimum sample volume required for analysis is 1 liter.
		Samples are prepared by extracting with a mixed solvent and are analyzed using GC/EC. A confirmatory analysis may be performed using a dissimilar second column or GC/MS.

SMEWW STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, SEVENTEENTH EDITION, 1989, ,

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SW846		
METHOD 6010	"Inductively Coupled Plasma Atomic Emission Spectroscopy"	This method is for the analysis of 25 metals. Sample matrices compatible with this method include ground water, soils and wastes. Minimum sample volume required for aqueous samples is 100 ml. One (1) gram is required for the analysis of solid samples. Samples are prepared using various digestion techniques (Reference SW846 Methods 3005-3050). Analysis is performed by ICP.
METHOD 7060	"Arsenic (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include ground water, soils, extracts and wastes. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using varios digestion techniques (Reference SW846 3005-3050). Analysis is performed by GFAA.
METHOD 7061	"Arsenic (Atomic Absorption, Gaseous Hydride)"	Sample matrices compatible with this method include ground water, soils, extracts and wastes. Minimum sample volume required for analysis is 50 ml for aqueous samples and 1 gram for solids. Samples are prepared using a nitric/sulfuric acid digestion. Analysis is performed by HYDAA.
METHOD 7090	"Beryllium (Atomic Absorption, Direct Aspiration)"	Sample matrices compatible with this method include waters and wastes. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using various digestion techniques (Reference SW846 Methods 3005-3050). Analysis is performed by FLAME.
METHOD 7091	"Beryllium (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include water and wastes. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using various digestion techniques (Reference SW846 Methods 3005-3050). Analysis is performed by GFAA.
METHOD 7130	"Cadmium (Atomic Absorption, Direct Aspiration)"	Sample matrices compatible with this method include water, wastes and sludge. Minimum sample volume required for analysis is 100 ml for aqueos samples and 1 gram for solids. Samples are prepared using various digestion techniques (Reference SW846 Methods 3005-3050). Analysis is performed by FLAME.
METHOD 7131	"Cadmium (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include water, soil and wastes. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids.

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METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SW846		Samples are prepared using various digestion techniques (Reference SW846 Methods 3005-3050). Analysis is performed by GFAA.
METHOD 7190	"Chromium (Atomic Absorption, Direct Aspiration)"	Sample matrices compatible with this method include water, soil and wastes. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using various digestion techniques (Reference SW846 Methods 3005-3050). Analysis is performed by FLAME.
METHOD 7191	"Chromium (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include water, soil and wastes. Minimum sample volume required for analysis is 100 ml for aqueous samples and 1 gram for solids. Samples are prepared using various digestion techniques (Reference SW846 Methods 3005-3050). Analysis is performed by GFAA.
METHOD 7195	"Chromium, Hexavalent (Coprecipitation)"	This method is for the analysis of dissolved hexavalent chromium in ground water and Extraction Procedure Toxicity (EP TOX) extracts. Minimum sample volume required for analysis is 50 ml. Analysis can be performed using either FLAME or GFAA. Samples should be stored at 4 degrees C until sample analysis.
METHOD 7196	"Chromium, Hexavalent (Colorimetric)"	This method is for the analysis of dissolved hexavalent chromium in Extraction Procedure (EP) toxicity characteristic extract and ground water. Minimum sample volume required for analysis is 100ml. Samples and extracts should be stored at 4 degress C until the time of analysis, which should be as soon as possible. Analysis is performed using spectrophotometer.
METHOD 7197	"Chromium, Hexavalent (Chelation/Extraction)"	This method is for the analysis of dissolved hexavalent chromium in Extraction Procedure (EP) Toxicity extract and ground water. Minimum sample volume required for analysis is dependent level of detection desired. amples and extracts should be stored at 4 degrees C until the time of nalysis, which should be as soon as possible. Analysis is performed by GFAA.
METHOD 7198	"Chromium, Hexavalent (Differential Pulse Polarography)"	This method is for the analysis of dissolved hexavalent chromium in Extraction Procedure (EP) Toxicity extract, natural water and waste water. Minimum samples volume required for analysis is dependent upon the level of detection desired.

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SW846		Samples and extracts should be stored at 4 degrees C until the time of analysis, which should be as soon as possible. Analysis is performed using polarographic instrumentation capable of differential pulse analysis.
METHOD 7420	"Lead (Atomic Absorption, Direct Aspiration)"	Sample matrices compatible with this method include water, wastes and sludge. Minimum sample volume required for analysis is 100ml for aqueous samples and 1g for soil samples. Samples are prepared using an appropriate digestion or dissolution procedure (methods 3005-3050). Analysis is performed using FLAME.
METHOD 7421	"Lead (Atomic Absorption, Furnace Technique)"	Sample matrices compatible with this method include water, wastes and . soils. Minimum sample volume required for analysis is 100ml for aqueous samples and 1g for soil samples. Samples are prepared using an appropriate digestion or dissolution procedure (method 3005-3050). Analyis is performed using GFAA.
METHOD 7470	"Mercury in Liquid Waste (Manual Cold-Vapor Technique)"	Sample matrices compatible with this method include ground water, aqueous wastes and mobility procedure extracts. Minimum sample volume required for analysis is 100 ml. Samples are subjected to a dissolution procedure prior to analysis. Analysis is performed using CVAA.
METHOD 7471	"Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)"	This method is for the analysis of inorganic and organic mercury. Sample matrices compatible with this method include soils, sludges and sediments. Minimum sample volume required for analysis is 0.2 gram. Samples are subjected to a dissolution procedure before analysis. Analysis is performed using CVAA.
METHOD 8010	"Halogenated Volatile Organics"	This method is for the analysis of 39 halogenated volatile organic compounds. Sample matrices compatible with this method include soil/sludge, groundwater liquid waste and water immiscible waste. Minimum sample volume required for analysis is 5 ml aqueous samples and 5 grams for solids. Samples are prepared by the purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed using GC/HSD. A confirmation may be done on a second column.
METHOD 8020	"Aromatic Volatile Organics"	This method is for the analysis of 8 aromatic volatile organic compounds. Samples matrices compatible with this method include soil/sludge,

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SW846		groundwater, liquid waste and water immiscible waste. Minimum sample volume is 5 grams for solids and 5ml for aqueous samples. Samples are prepared by purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed using GC/PID. A confirmation may be made on a second column.
METHOD 8060	"Phthalate Esters"	This method is for the analysis of 6 phthalate esters. Sample matrices compatible with this method include water, soil, sludge and water immiscible waste. Minimum sample volume required for the analysis of aqueous samples is 1 liter. Sample volume for solids is dependent upon the level of detection desired. Aqueous samples are prepared by a separatory funnel or continuous liquid-liquid extraction. Solid samples are prepared by a soxhlet or sonication extraction. Analysis is performed by GC/EC or GC/FID. A confirmatory analysis may be performed using a second column.
METHOD 8080	"Organochlorine Pesticides and PCBs"	This method is for the analysis of 26 organochlorine pesticides and aroclors. Sample matrices compatible with this method include water, soil, sludge and water immiscible wastes. Minimum sample volume required for analysis is 1 liter for aqueous samples. Sample volume for solids is dependent upon the level of detection desired. Aqueous samples are prepared using a separatory funnel or continuous liquid-liquid extraction. Soil samples are prepared using soxhlet or sonication extraction. Analysis is performed by either GC/EC or GC/HSD. A confirmatory analysis may be performed using a second column or GC/MS.
METHOD 8100	"Polynuclear Aromatic Hydrocarbons"	This method is for the analysis of 24 polynuclear aromatic hydrocarbons. Sample matrices compatible with this method include ground water, surface water, drinking water and soil/sediments. Minimum sample volume required for aqueous samples is 1 liter. Sample volume for soil samples is dependent upon the level of detection desired. Aqueous samples are prepared using a separatory funnel or continuous liquid-liquid extraction. Soil samples are prepared using a soxhlet or sonication extraction. Analysis is performed by GC/FID. A confirmatory analysis may be performed using a second column or GC/MS.
METHOD 8240	"Gas Chromatography/Mass Spectrometry for Volatile Organics"	This method is for the analysis of 51 volatile organic compunds. Sample matrices include groundwater, liquors, and soil/sediment. Minimum sample volume is 5ml for aqueous samples and 5g for solids. Samples are prepared by purging the sample with an inert gas and trapping on a sorbent material. Analysis is performed by GC/MS.
METHOD 8250	"Gas Chromatography/Mass Spectrometry for	This method is for the analysis of 131 semivolatile organic compounds.

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METHOD TITLES AND ABSTRACTS

METHOD REFERENCE	TITLE OF METHOD	SUMMARY OF METHOD
SW846	Semivolatile Organics: Packed Column Technique"	Sample matrices compatible with this method include solid waste, soils and ground water. Minimum sample volume required for analysis is 1 liter for aqueous samples. Soil sample volume is dependent upon detection limit. Samples are prepared using purge and trap technique. Analysis is performed using GC/MS.
METHOD 8270	"Gas Chromatography/Mass Spectrometry for Semivolatile Organics: Capillary Column Technique"	This method is for the analysis of 131 semivolatile compounds. Sample matrices compatible with this method include groundwater, wastes and soil. Minimum volume required for analysis is 1 liter for aqueous samples. Soil sample volume is dependent upon level of detection desired. Soil samples are prepared using soxhlet or sonication extration. Aqueous samples may be prepared by separatory funnel or con- tinuous liquid-liquid extraction. Analysis is performed by GC/MS.
METHOD 8310	"Polynuclear Aromatic Hydrocarbons"	This method is for the analysis of 16 polynuclear aromatic hydrocarbons. Sample matrices compatible with this method include waters, soil, waste and sludge. Minimum sample volume required for analysis of aqueous samples is 1 liter. Sample volume for solid samples is dependent upon the level of detection desired. Aqueous samples are prepared using a separatory funnel or continuous liquid-liquid extraction. Solid samples are prepared by either a soxhlet or sonication extraction. Analysis is performed by HPLC.

SW846 TEST METHODS FOR EVALUATING SOLID WASTE, THIRD EDITION, 11/86, OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE,

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Table V- A
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS

Organic Compounds

Drinking Water (USEPA, Office of Water)

Compound Class	EPA Method No.	Analytical System	Sample Introduction/ Preparation	Detection Range (ppb)
Acrolein and Acrylonitrile	603	GC/FID	P&T	0.5-0.6
Base/Neutrals, Acids and Pesticides	625*	GC/MS	XTN	.09-44.0
Benzidines	605	HPLC/Electrochem	XTN	0.08-0.13
Carbamates and Urea Pesticides	632	HPLC/UV	XTN	0.003-11.1
Chlorinated Acids	515.1	ECD Capillary Column	XTN	EDL, 0.1-1.0
Chlorinated Hydrocarbons	612	GC/ECD	XTN	0.03-1.34
Chlorinated Pesticides	508	ECD Capillary Column	XTN	EDL, 0.01-0.5 (most <0.1)
1,2-Dibromoethane and 1,2-Dibromo-3-Chloropropane	504	GC/ECD	XTN	0.01
Dithiocarbamate Pesticides	630	Colorimetric	CS_2 Liberation	1.9-15.3
Extractable Organics	525*	GC/MS Capillary Column	XTN	0.1-1.0
Haloethers	611	GC/HECD	XTN	0.3-3.9
Nitroaromatics and Isophorone	609	GC/FID + ECD	XTN	0.01-15.7
Nitrogen and Phosphorous Containing Pesticide	507	NPD Capillary Column	XTN	EDL (Estimated D.L.) 0.1-5.0 (most <1.0)
Nitrosamines	607	GC/NPD	XTN	0.15-0.81
N-Methylcarbamates and N Methylcarbamoyloximes	531.1	HPLC Fluorescence Detector	DI	0.5-4.0
Organohalide Pesticides and PCBs	617	GC/ECD	XTN	0.002-0.176
Organophosphate Pesticides	614	GC/FPD or NPD	XTN	0.012-0.015
Organophosphate Pesticides	622	GC/FPD	XTN	0.1-5.0
Perchlorination Screening of PCBs	508A	ECD/HECD Packed or Capillary Column	XTN	0.1-0.3
Pesticide and PCBs	505*	GC/ECD Capillary Column	XTN	Variable Pesticide 0.005-1.0 Herbicide 0.2-7.0 PCBs 0.1-0.5
Pesticides and PCBs Organchlorine	608*	GC/ECD	XTN	0.002-0.24
Phenols	604	GC/FID	XTN	0.14-16.0
Phthalate Esters	606	GC/ECD	XTN	0.29-3.0
Purgeable Aromatics	602*	GC/PID	P&T	0.2-0.4

* Frequently requested method.

APPENDIX III

Table V- A
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS

Organic Compounds (continued)

Industrial and Municipal Waste Water (USEPA, Office of Research and Development)

Compound Class	EPA Method No.	Analytical System	Sample Introduction/ Preparation	Detection Range (ppb)
Purgeable Halocarbons	601*	GC/HECD	P&T	0.02-1.81
Purgeable Organics	524.1	GC/MS Capillary Column	P&T	0.1-1.0
Purgeable Organics	524.2*	GC/MS Capillary Column	P&T	0.02-0.2
Purgeables	624*	GC/MS	P&T	1.6-7.2
Volatile Aromatics and Unsaturated Compounds	503.1	GC/PID	P&T	0.002-0.03
Volatile Halocarbons	502.1	GC/ECD Packed Column	P&T	0.001-0.01
Volatile Halocarbons	502.2*	GC/HECD/PID Capillary Column	P&T	0.01-0.10
2,3,7,8-Tetrachlorodibenzo-p dioxin	613	GC/MS	XTN	0.002
Triazine Pesticides	619	GC/NPD	XTN	0.03-0.07

Aqueous and Solid Matrices (USEPA, Office of Water)

Compound Class	EPA Method No.	Analytical System	Sample Introduction/ Preparation	Detection Range (ppb)
Semivolatile Organics	1625	Isotope Dilution by GC/MS (Capillary Column)	XTN	most 20-100 ppb (dependent on % solids)
Tetra- through octa-chlorinated dioxins and furans	1613	Isotope Dilution by high resolution GC/high resolution MS	XTN	10-100 parts per quadrillion in water 1-10 parts per trillion in soil
Volatile Organics	1624	Isotope Dilution by GC/MS (Capillary Column)	P&T	5-100 ppb (dependent on % solids)

* Frequently requested method.

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Table V- A
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS

Organic Compounds (continued)

Solid Matrices (USEPA, Test Methods for Evaluating Solid Waste, SW846, November, 1986.)

Compound Class	EPA Method No.	Analytical System	Sample Introduction/ Preparation	Detection Range (ppb)
Acrolein, Acrylonitrite, Acetonitrile	8030	GC/FID	5030	0.5-0.6
Aromatic Volatile Organics	8020*	GC/FID	5030	0.2-0.4
Chlorinated Herbicides	8150	GC/ECD or HECD	3550	0.1-200
Chlorinated Hydrocarbons	8120	GC/ECD	3550	0.03-1.3
Nitroaromatics and Cyclic Ketones	8090	GC/FID or ECD	3550	0.06-5.0
Organophosphorus Pesticides	8140	GC/FPD or NPD	3550	0.1-5.0
Organochlorine Pesticides and PCBs	8080*	GC/ECD	3550	70-1000
Phenols	8040	GC/FID	3550	0.14-16
Phthalate Esters	8060	GC/ECD	3550	0.29-31
Polynuclear Aromatic Hydrocarbons	8100	GC/FID	3550	Not Reported
Polynuclear Aromatic Hydrocarbons	8310	HPLC/UV and Fluor	3550	0.013-2.3
Purgeable Halogenated Volatile Organics	8010	GC/HECD	5030	0.03-0.52
Purgeable Non-Halogenated Volatile Organics	8015	GC/FID	5030	Not Reported
Semivolatile Organics	8270*	GC/MS Capillary Column	3550	Not Reported
Volatile Organics	8240*	GC/MS	5030	1.6-7.2

* Frequently requested method.

APPENDIX III

Table V- A
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS

Organic Compounds (continued)

Sample Preparation Method Used:

XTN	Extraction Methods that could be used include 3510, 3520, 3540 and 3550
P&T	Purge and Trap
DI	Direct Injection of liquid samples; solid samples mixed then injected.
3510	Separatory Funnel Extraction of Liquid Samples
3520	Liquid-Liquid Extraction
3540	Soxhlet Extraction of Solid Samples
3550	Sonication Extraction of Solid Samples
5030	Purge and Trap.

Nomenclature:

Instruments:

GC = Gas Chromatograph

GC/MS = Gas Chromatograph/Mass Spectrometer

HPLC = High Performance Liquid Chromatograph

Detectors:

ECD = Electron Capture

FID = Flame Ionization

Fluor = Fluoresence

FPD = Flame Photometric

HECD = Hall Electrodyte Conduction

NPD = Nitrogen/Phosphorus

PID = Photoionization

UV = Ultraviolet

APPENDIX III
TABLE V-B
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS
INORGANIC ANALYTES

Analyte	EPA Method No.	Analytical System	Sample Preparation	Detection Range (ppb)
Total/Dissolved Metals	1620	ICP	3005,3010	
Total/Dissolved Metals	6010	ICP	3005,3010	
Total/Dissolved Metals	7000	AA	3005,3010	1,000
Aluminum	200.7 CLP	ICP	1	200
Aluminum	202.1 CLP	AA	1	100
Aluminum	202.2 CLP	GFAA	1	3
Aluminum	7020	AA	3005,3010	4300-5700
Antimony	200.7 CLP	ICP	1	60
Antimony	204.1 CLP	AA	1	20
Antimony	204.2 CLP	GFAA	1	
Antimony	7040	AA	3005,3010	70
Antimony	7041	GFAA	3005,3010,3020	20
Arsenic	200.7 CLP	ICP	1	25
Arsenic	206.2	GFAA	1	
Arsenic	206.3	AA-Hydride	2	10
Arsenic	206.4	Spectrophotometric	6	10
Arsenic	7060	GFAA	3020	1
Arsenic	7061	AA-Hydride	3005,3010	10
Barium	200.7 CLP	ICP	1	200
Barium	208.1 CLP	AA	1	100
Barium	208.2 CLP	GFAA	1	2
Barium	7080	AA	3005,3010	30
Barium	7081	GFAA	Nitric acid, reflux	2
Beryllium	200.7 CLP	ICP	1	5
Beryllium	210.1 CLP	AA	1	5
Beryllium	210.2 CLP	GFAA	1	
Beryllium	7090	AA	3005,3010	460-540
Beryllium	7091	GFAA	3020	5
Boron	212.3	Spectrophotometric	Hydrochloric acid	200
Cadmium	200.7 CLP	ICP	1	5
Cadmium	213.1 CLP	AA	1	5
Cadmium	213.2 CLP	GFAA	1	
Cadmium	7130	AA	3005,3010	2
Cadmium	7131	GFAA	3020	5
Calcium	200.7 CLP	ICP	1	5,000
Calcium	215.1 CLP	AA	1	
Calcium	215.2	Titrimetric	1	100,000
Calcium	7140	AA	3005,3010	4800-5200
Chromium	200.7 CLP	ICP	1	10
Chromium	218.1 CLP	AA	1	50
Chromium	218.2 CLP	GFAA	1	1
Chromium	218.3	AA-Chelate	2	
Chromium Hexavalent	218.4	AA	2	

APPENDIX III
TABLE V-B
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS
INORGANIC ANALYTES
(continued)

Analyte	EPA Method No.	Analytical System	Sample Preparation	Detection Range (ppb)
Chromium Dissolved, Hexavalent	218.5	GFAA	2	
Chromium	7190	AA	3005,3010	3300-6700
Chromium	7191	GFAA	3020	5
Chromium	7195	Coprecipitation AA, GFAA	Nitric acid, hydrogen peroxide	See 7190,7191
Chromium, Hexavalent	7196	colorimetric	Aqueous, acetic acid extract (EP)	500
Chromium, Hexavalent	7197	Chehtion/ extraction,AA	Aqueous, acetic acid extract (EP)	500 3000
Chromium, Hexavalent	7198	Differential Pulse Polarography	Aqueous, acetic acid extract (EP)	10
Cobalt	200.7 CLP	ICP	1	50
Cobalt	219.1 CLP	AA	1	50
Cobalt	219.2 CLP	GFAA	1	1
Cobalt	7200	AA	3005-3010	3400-4600
Cobalt	7201	GFAA	3020	50
Copper	200.7 CLP	ICP	1	25
Copper	220.1 CLP	AA	1	20
Copper	220.2 CLP	GFAA	1	1
Copper	7210	AA	3005,3010	3700-4300
Copper	7211	GFAA	Nitric acid, reflux	1
Cyanide	335.2	Total, Titrimetric, Spectrophotometric	4	10
Cyanide	335.2	Midi, Distillation Total, Colorimetric, Automated UV	4	5
Cyanide	355.1	Amenable to Chlorination/ Titrimetric, Spectrophotometric	5	10
Cyanide, amendable to chlorination, after distillation	4500-CN-G Standard Method for the Examination of Water and Wastewater 1989	Titrimetic colorimetric, ion selective electrode	Alkaline distillation distillation	10
Cyanide, Amendable to Chlorination, without distillation	4500-CN-H Standard Method for the Examination of Water and Wastewater 1989	Spectrophotmetric	pH greater than 12	20

APPENDIX III
TABLE V-B
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS INORGANIC ANALYTES
(continued)

Analyte	EPA Method No.	Analytical System	Sample Preparation	Detection Range (ppb)
Cyanide, Weak and dissociable	4500-CN-I Standard Method for the Examination of Water and Wastewater 1989	Titrimetic, colorimetric, ion selective electrode	pH greater than 12	10
Cyanide	335.3	Total, Spectrophotometric	4	10
Gold	231.1	AA	Nitric acid, Aqua Regia	100
Gold	231.2	GFAA	Nitric acid, Aqua Regia	1
Iron	200.7 CLP	ICP	1	100
Iron	236.1 CLP	AA	1	30
Iron	236.2 CLP	GFAA	1	1
Iron	7380	AA	3005,3010	4400-5600
Iron	7381	GFAA	Nitric acid, reflux	1
Iridium	235.1	AA	Nitric acid, Aqua Regia	3000
Iridium	235.2	GFAA	Nitric acid, Aqua Regia	30
Lead	200.7 CLP	ICP	1	30
Lead	239.1 CLP	AA		100
Lead	239.2 CLP	GFAA	1	1
Lead	7420	AA	3005,3010	50
Lead	7421	GFAA	3020	1
Magnesium	242.1 CLP	AA	1	100
Magnesium	7450	AA	3005,3010	970-1030
Manganese	200.7 CLP	ICP	1	15
Manganese	243.1 CLP	AA	1	10
Manganese	243.2 CLP	GFAA	1	0.2
Manganese	7460	AA	3005,3010	10
Manganese	7461	GFAA	Nitric acid, reflux	0.2
Mercury	245.1 CLP	Cold Vapor AA/Manual Aqueous	3	0.2
Mercury	245.2 CLP	CVAA/ Automated/ Aqueous	3	0.2
Mercury	245.5 CLP	CVAA/Manual/ Sediment	3	0.2

APPENDIX III
TABLE V-B
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS
INORGANIC ANALYTES
(continued)

Analyte	EPA Method No.	Analytical System	Sample Preparation	Detection Range (ppb)
Mercury	7470	CVAA/ Liquids	3	0.2
Mercury	7471	CVAA/Solids	3	0.2
Molybdenum	246.1	AA	2	100
Molybdenum	246.2	GFAA	2	1
Molybdenum	7480	AA	3005,3010	10,000
Molybdenum	7481	GFAA	3020	-
Nickel	200.7 CLP	ICP	1	40
Nickel	249.1 CLP	AA	1	40
Nickel	249.2 CLP	GFAA	1	1
Nickel	7520	AA	3005,3010	4900-5100
Osmium	252.1	AA	Nitric,sulfuric acids	300
Osmium	252.2	GFAA	Nitric acid	20
Osmium	7550	AA	3005,3010	-
Palladium	253.1	AA	Nitric acid	100
Palladium	253.2	GFAA	Nitric acid	5
Platinum	255.1	AA	2	1000
Platinum	255.2	GFAA	2	20
Potassium	200.7 CLP	ICP	1	5000
Potassium	258.1 CLP	AA	1	10
Potassium	7610	AA	3005,3010	1000-2200
Rhenium	264.1	AA	Nitric acid	5000
Rhenium	264.2	GFAA	Nitric acid	200
Rhodium	265.1	AA	Nitric acid Regia	50
Rhodium	265.2	GFAA	Nitric acid	5
Ruthenium	267.1	AA	Hydrochloric acid	200
Ruthenium	267.2	GFAA	Hydrochloric acid	20
Selenium	200.7 CLP	ICP	1	5
Selenium	270.2 CLP	GFAA	1	2
Selenium	270.3	AA-Hydride	2	-
Selenium	7740	GFAA	3020	3-5
Selenium	7741	AA Hydride	3005,3010	4
Silver	200.7 CLP	ICP	1	10
Silver	272.1 CLP	AA	1	10
Silver	272.2 CLP	GFAA	1	0.2
Silver	7760	AA	3005,3010	1200-2800
Silver	7761	GFAA	Nitric acid, reflux	0.2
Sodium	200.7 CLP	ICP	1	5000
Sodium	273.1 CLP	AA	1	2
Sodium	273.2 CLP	GFAA	2	1-30
Sodium	7770	AA	3005,3010	4800-5200
Thallium	200.7 CLP	ICP	1	10

APPENDIX III
TABLE V-B
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS
INORGANIC ANALYTES
(continued)

Analyte	EPA Method No.	Analytical System	Sample Preparation	Detection Range (ppb)
Thallium	279.1 CLP	AA	1	100
Thallium	279.2 CLP	GFAA	1	1
Thallium	7840	AA	3005,3010	-
Thallium	7841	GFAA	3020	1-10
Tin	282.1	AA	2	800
Tin	282.2	GFAA	2	5
Titanium	283.1	AA	2	400
Titanium	283.2	GFAA	2	10
Vanadium	200.7 CLP	ICP	1	50
Vanadium	286.1 CLP	AA	1	200
Vanadium	286.2 CLP	GFAA	1	4
Vanadium	7910	AA	3005,3010	49400-50600
Vanadium	7911	GFAA	3020	50
Zinc	200.7 CLP	ICP	1	20
Zinc	289.1 CLP	AA	1	5
Zinc	289.2 CLP	GFAA	1	0.05
Zinc	7950	AA	3005,3010	5
Zinc	7951	GFAA	Nitric acid, reflux	0.05

APPENDIX III
TABLE V-B
COMPARISON OF ROUTINE METHODS BY MAJOR CHARACTERISTICS
INORGANIC ANALYTES
(continued)

Sample Preparation Methods

3005 Acid Digestion of Waters for Total Recoverable Dissolved Metals for Analysis by Flame Atomic Absorption Spectroscopy or Inductively Coupled Plasma Spectroscopy.

3010 Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by Flame Atomic Absorption Spectroscopy or Inductively Coupled Plasma Spectroscopy.

3020 Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by Furnace Atomic Absorption Spectroscopy.

1. CLP preparation methods are categorized by water/soil, ICP, AA, and GFAA instrumentation.

CLP methods are based on the 200 series Methods for Chemical Analysis of Water and Wastes. U.S. Environmental Monitoring and Support Laboratory. Cincinnati, Ohio March, 1983.

1.1 Water sample preparation for GFAA uses nitric acid, hydrogen peroxide and mild heat. SOW 788, D-5.

1.2 Water sample preparation for ICP and AA uses nitric acid, hydrochloric acid and mild heat. SOW 788, D-5.

1.3 Soil sample preparation for ICP, AA, GFAA uses nitric acid, hydrogen peroxide, and mild heat. Hydrochloric acid is used as the final reflux acid for several analytes. SOW 788, D-5,6.

2. Nitric and hydrochloric acids are used for digestion.

3. Mercury is prepared using a permanganate/persulfate oxidation procedure.

4. Total cyanide is determined by a reflux-distillation procedure using a sodium hydroxide scrubber.

5. Cyanide amenable to chlorination is chlorinated at pH greater than 11.

6. EPA Method 206.5 details the sample preparation for arsenic.

APPENDIX IV
CALCULATION FORMULAS FOR STATISTICAL EVALUATION

Appendix IV provides calculation formulass to enable responsible risk assessment personnel samples necessary to meet statistical performance objectives. This appendix also provides statistical guidelines on the probability that a given sampling plan will identify a hot spot, and the probability that no hot hot spot exists given none was found after sampling.

CALCULATION FORMULAS TO DETERMINE THE NUMBER OF SAMPLES REQUIRED GIVEN COEFFICIENT OF VARIATION AND STATISTICAL PERFORMANCE OBJECTIVES

The minimum number of samples, n, required to achieve a specified precision and confidence level at a defined minimum detectable relative difference may be estimated by the use of one of the following equations below.

Equation # 1: for one-sided, one-sample t-test $n \geq [(Z\alpha + Zb)/D]^2 + 0.5Z^2\alpha$

Equation # 2: for a one-sided, two-sample t-test $n \geq 2[(Z\alpha + Zb)/D]^2 + 0.25Z^2\alpha$

where: $Z\alpha$ is a percentile of the standard normal distribution such that $P(Z \geq Z\alpha) = \alpha$, $Z\beta$ is similiarly defined, and D = minimum relative detectable difference/CV. CV = coefficient of variation. For a two-sided t-test, the values for $Z\alpha$ should be changed to $Z\alpha/2$. NOTE: Data must be transformed ($Z\alpha$).

As an example of application of the first equation above, assume CV = 30%, Confidence Level = 80%, Power = 95%, and Minimum Detectable Relative Difference = 20%. For infinite degrees of freedom (t distribution becomes a normal one) $Z\alpha = 0.842$ and $Z\beta = 1.645$. From the data assumed, D = 20%/30%. Therefore,

$$n \geq [(0.842 + 1.645)/(20/30)]^2 = 0.5\,(0.842)^2$$

$$n \geq 13.917 + 0.354 = 14.269$$

$n \geq 15$ sample required (round up)

Source: Adapted from EPA 1990c.

APPENDIX IV
(continued)

CALCULATION FORMULAS FOR THE STATISTICAL EVALUATION OF THE DETECTION OF HOT SPOTS

Hot Spot Will Be Identified: Example # 1

These formulas are useful to evaluate the probability that a particular sampling plan will identify a hot spot. Let R represent the radius of a hot spot and D be the distance between adjacent grid points where samples will be collected. The probability that a grid point will fall on a hot spot is easily obtained from a geometrical argument since at least one grid point must fall in any square of area D^2 centered at the center of the hot spot. From this concept, it follows that the probability of sampling a hot spot P(H) is given by:

$$\begin{aligned} P(H) &= (\pi R^2)/D^2 \qquad \text{if } R \leq D/2 \\ &= \{R^2 [\pi - 2 \text{ arc cos } (D/(2R))] + (D/4)\sqrt{(4R^2 - D^2)}\}/D^2 \qquad \text{if } D/2 < R < D\sqrt{2}/2 \\ &= 1 \qquad \text{if } R \geq D\sqrt{2}/2 \end{aligned}$$

where the angle with cosine as D/(2R) is expressed in radian measure.

An example is if the grid spacing is taken to be D = 2R and the probability of a hit is $\pi/4 = 0.785$, which implies that the probability that this grid spacing would not hit a hot spot if it exists is 0.215.

No Hot Spot Exists: Example # 2

This set of formulas addresses the second question concerning the probability that no hot spot exists (given that none were found). This argument requires the use of a subjective probability, P(E), based on historical and perhaps geophysical evidence of the existence of a hot spot on the site. Then, if E is the event that there are no hot spots at the study site and if H is the event that no hot spot is sampled in the survey, Bayes formula gives:

$$\begin{aligned} P(E \mid \bar{H}) &= P(\bar{H} \mid E)\, P(E) / [P(\bar{H} \mid E)\, P(\bar{E}) + P(\bar{H} \mid \bar{E})\, P(\overline{\bar{E}})] \\ &= P(H \mid E)\, P(E) / P(H \mid E)\, P(E) + P(E)]. \end{aligned}$$

For the case where D = 2R, it was found that P(H|E) =0.215, so if one is given that the chance P(E) of a hot spot is thought to be 0.25 prior to the investigation, the probability of a hot spot existing if the study does not find a hot spot is:

$$P(E \mid \text{no hit}) = 0.215\,(0.25) / [0.215\,(0.25) + 0.75] = 0.067.$$

Hence, the probability that no hot spot exists is (1-0.067) = 0.933.

Source: Adapted from EPA 1990c.

APPENDIX V

"J" DATA QUALIFIER SOURCE AND MEANING

Appendix V lists the parameters and criteria that produce a "J" flag in accordance with the Laboratory Data Validation Functional Guidelines for Organics and Inorganics Analyses (EPA 1988) as applied to data from the Contract Laboratory Program. The appendix also indicates the likely implication of this flag on the associated result(s).

The criteria listed in this document should be used to flag CLP data as "J", or estimated concentration (the associated numerical value is an estimate of the amount actually present in the sample). With proper interpretation, the results of analytes which are flagged "J" can often be used in making decisions.

ANALYSIS: Organic (2/88) VOA & BNA

PARAMETER	CRITERIA	ACTION	LIKELY IMPLICATION[1]
Holding times	>14 <30 days	Associated samples (+ results)	L
Mass Calibration			N
Ion Abundance	Several data elements in expanded window	All associated data	L P
Calibrations - initial	Average RRF < .05 %RSD > 30%	Compound specific (+ results) Compound specific (+ results)	L
- continuing	Average RRF < .05 %D between initial and continuing calibration > 25%	Compound specific (+ results) Compound specific (+ results)	P
Blanks	If associated result is between detection limit and CRQL	Compound specific	H

---

[1] Implication Key

L =	Low: The associated result may underestimate the true value.
H =	High: The associated result may overestimate the true value.
P =	Precision: The associated result may be of poor precision (high variabity).
N =	No generalization: No generalization can be made as to the likely implication.

APPENDIX V (CONTINUED)

PARAMETER	CRITERIA	ACTION	LIKELY IMPLICATION[1]
Surrogates	If surrogate recoveries are low but > 10%	Fraction specific (+ results) (negative results are flagged w/sample quantitation limit as estimated (UJ)	L
	Any surrogate in a fraction shows < 10% recovery	Fraction specific positive results	L
	If surrogate recoveries are high	Fraction specific (+ results)	H
Internal standards	If an IS area count is outside -50% or +100% of the associated standard	Associated compounds (+ results) (non-detects flagged w/sample quantitation limit - UJ)	N
TICs	None	All TIC results - (NJ)	N
ANALYSIS: Pesticides (2/88)			
Holding Times	>7 days <30 days	Associated positive results (negative results - UJ)	L
Instrument Performance	DDT breakdown >20%	Associated positive DDT results (J)	L
		Results for DDD and/or DDE (NJ)	L
	Endrin breakdown >20%	Associated positive Endrin results (J) Results for endrin ketone (NJ)	
Calibration - initial	If criteria for linearity not met	Associated positive results	N
	If %D between calibration factors >15% (20% for compounds being configured)	Associated positive results	N

APPENDIX V (CONTINUED)

PARAMETER	CRITERIA	ACTION	LIKELY IMPLICATION[1]
LCS (Solid)	Recovery outside EPA control limits	Associated samples >IDL	L/H
	Recovery lower than EPA control limits	Associated samples [<IDL (UJ)]	L
Duplicate	Outside appropriate control windows	Associated samples of same matrix	P
Matrix Spike Sample	Recovery >125% or <75% Recovery within range 30-74%	Associated samples >IDL Associated samples [<IDL (UJ)]	L/H
AA Post Digestion Spike	Duplicate injection outside + 20% RSD (or CV) and sample not rerun once	Associated data	P
	Rerun sample does not agree within + 20% RSD (CV)	Associated data	P
	Post digestion spike recovery <40%	Associated data >IDL	L
	Post digestion spike recovery >115, or <85%	Associated data [<IDL (UJ)]	H/L
	If sample absorbance is <50% of post digestion spike absorbance and if furnace post digestion spike recovery not within 85 - 115%	Associated samples >IDL [<IDL (UJ)	L/H
	MSA not done	Associated data	P
	Any samples run by MSA not spiked at appropriate levels	Associated data	N
	MSA correlation coefficient <0.995	Associated data	N
ICP Serial Dilution	Criteria not met	Associated data	P

APPENDIX V (CONTINUED)

PARAMETER	CRITERIA	ACTION	LIKELY IMPLICATION[1]
Surrogates	If low surrogate recoveries obtained	Associated results	L
Compound Quantitation, and Detection Limits	Quantitation limits affected by large, on-scale peaks	Estimate quantitation limit (UJ)	N
ANALYSIS: Inorganic (7/88)			
Holding Times/Preservation	Not met	Associated samples >IDL [<IDL (UJ)]	L
Calibrations	Correlation coefficient <0.995	Associated samples >IDL (J), <IDL (UJ)	N
	Midrange CN- standard not distilled	Associated samples	P
ICV or CCV	%R outside windows but within the ranges of 75-89% or 111-125% (CN, 78-84% or 116-130%; Hg, 65-79% or 121-135%)	Associated samples >IDL	L/H
ICS (for ICP)	If ICS recovery >120%	Associated samples >IDL	H
	If ICS recovery falls between 50-79%	Associated samples >IDL [<IDL (UJ)]	L
	Comparable or higher levels of interferents and with analyte concentrations - ICS	Associated samples (>IDL) [(<IDL) (UJ)]	H
	Al, Ca, Fe, and Mg interfering elements >2XCRDL and 10% reported concentration of the affected element	Associated samples	H
LCS (Aqueous)	Recovery within range 50-79% or >120%	Associated samples >IDL [<IDL (UJ)]	L/H

APPENDIX V (CONTINUED)

Selected Acronym Key

CRDL -- Contract Required Detection Limit (CLP inorganics)

CRQL -- Contract Required Quantitation Limit (CLP organics)

CV -- Coefficient of Variation

ICS -- Interference Check Sample

ICV -- Initial Calibration Verification

IDL -- Instrument Detection Limit

IS -- Internal Standard

LCS -- Laboratory Control Sample

RRF -- Relative Response Factor

RSD -- Relative Standard Deviation

TIC -- Tentatively Identified Compound

APPRNDIX VI

"R" DATA QUALIFIER SOURCE AND MEANING

Appendix VI lists the parameters and criteria that produce an "R" flag in accordance with the Laboratory Data Validation Functional Guidelines for Organics and Inorganics Analyses (EPA 1988) as applied to data from the Contract Laboratory Program. The appendix also indicates the likely implication of this flag on the associated result(s).

The criteria listed in this document should be used to flag CLP data as "R", or unuseable. If the flagged analytes are of interest, then resampling or reanalysis is necessary.

PARAMETER	CRITERIA	ACTION	LIKELY IMPLICATION[1]
ANALYSIS: Organic (2/88) VOA & BNA			
Holding times	Grossly exceeded	Professional Judgement (Non-Detects)	L
Mass Calibration	In error	Associated Samples	U
Ion Abundance	Outside Expanded Windows	Associated Samples	U
Calibrations	RRF or RRF <0.05	Compound Specific (Non-Detects)	L
Blanks	Gross Contamination (Saturated Peaks)	Compound Specific (Assoc. Samples)	H
Surrogates	<10% Recovery	Entire Fraction (Negative Results)	L
Internal Standards	Extremely Low Area Counts; Major Abrupt Dropoff	Associated Compounds (Non-Detects)	L
TICs	Suspected Artifacts	Professional Judgment	U
ANALYSIS: Pesticides (2/88)			
Holding Times	Grossly Exceeded	Professional Judgment (Non-Detects)	L

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[1] Implication Key

L = Low: The associated result may underestimate the true value.

H = High: The associated result may overestimate the true value.

P = Precision: The associated result may be of poor precision (high variabity).

N = No generalization: No generalization can be made as to the likely implication.

APPENDIX VI (CONTINUED)

PARAMETER	CRITERIA	ACTION	LIKELY IMPLICATION[1]
Instrument Performance			
- DDT Retention Time	Inadequate Separation	Affected Compounds	U
- RT	Peaks of Concern Outside Windows	Professional Judgment (Positive Results and Quantitation Limits)	U
- DDT/Endrin Degradation	Not Detected and Breakdown Concentrations Positive	Samples Following Last In-Control Standard (Quantitation Limit - DDT and Endrin)	L
- Retention Time Check	DBC > 2.0% (Packed) >0.3% (Narrow-Bore) >1.5% (Wide-Bore)	Professional Judgment	U
Surrogates	Not Present	Suggested (Negative Results)	L
Compound Quantitation, and Detection Limits	Large Off-Scale Peaks	Quantitation Limits	U
ANALYSIS: Inorganic (7/88)			
Holding Times	Exceeded	Professional Judgment (Results <IDL)	L
Calibrations	Minimum Number of Standards Not Used; Not Calibrated Daily or Each Time Instrument Set Up	Associated Samples	P
- ICV or CCV	%R Outside Windows	Projessional Judgment with Recommendations	L/H
ICS (for ICP)	Al, Ca, Fe or Mg in Samples ≤ ICS and ICS <50%	Affected Analytes	L
LCS (Aqueous)	Recovery < 50%	Affected Analytes	L
Matrix Spike Sample	Recovery < 30%	Affected Samples (Results <IDL)	L
AA Post Digestion Spike	Recovery < 10%	Affected Samples (Results <IDL)	L

APPENDIX VI (CONTINUED)

Selected Acronym Key

CCV -- Continuing Calibration Verification

DBC -- Dibutyl Chlorendate

ICP -- Inductively Coupled Plasma Atomic Emission Spectroscopy

ICS -- Interference Check Sample

ICV -- Initial Calibration Verification

IDL -- Instrument Detection Limit

LCS -- Laboratory Control Sample

APPENDIX VII

SUMMARY OF COMMON LABORATORY CONTAMINANTS, CONCENTRATION REQUIREMENTS, AND RISK ASSESSMENT IMPLICATIONS

Appendix VII lists common organic laboratory contaminants that may appear in blanks. The purpose of this appendix is to inform the reader of chemicals that may appear in analyses but may not be present at the site. The implications for risk assessment are included.

Common Laboratory Contaminants	Concentration Requirements	Risk Assessment Implications
Target Compound		
Methylene Chloride	Sample concentrations less than 10X that detected in method blanks will be reported as undetected.	Include analyte if concentration is greater than 10X blank. Include analyte if concentration is less than 10X greater than blank concentration and multiple chlorinated analytes are detected. Exclude analyte in all other situations.
Acetone	Sample concentrations less than 10X that detected in method blanks will be reported as undetected.	Include analyte if concentration is greater than 10X blank. Include analyte if concentration is less than 10X greater than blank concentration and multiple ketones are detected. Exclude analyte in all other situations.
Toluene	Sample concentrations less than 10X that detected in method blanks will be reported as undetected.	Include analyte if concentration is greater than 10X blank. Include analyte if concentration is less than 10X greater than blank concentration and multiple aromatic or fuel hydrocarbons are detected. Exclude analyte in all other situations.

APPENDIX VII (CONTINUED)

Common Laboratory Contaminants	Concentration Requirements	Risk Assessment Implications
2-Butanone (methyl ethylketone)	Sample concentrations less than 10X that detected in method blanks will be reported as undetected.	Include analyte if concentration is greater than 10X blank. Include analyte if concentration is less than 10X greater than blank concentration and mutiple ketones are detected.
Tentatively Identified Compounds		
Carbon dioxide	Not reported if present in the method blank.	Exclude analyte in all situations.
Diethyl ether	Not reported if present in the method.	Exclude analyte in all situations.
Hexanes	Not reported if present in the method blank.	Exclude if analyte concentration not 10X method blank. Exclude if analyte concentration not 10X field blank (EPA definition). Exclude if sample not analyzed within 7 days.
Freons (i.e., 1,1,2-trichloro-1,2,2-trifluroethane, fluorotrichloromethane)	Not reported if present in the method blank.	Exclude if analyte concentration not 10X method blank. Exclude if analyte concentration not 10X field blank (EPA definition). Exclude if sample not analyzed within 7 days.

APPENDIX VII (CONTINUED)

Common Laboratory Contaminants	Concentration Requirements	Risk Assessment Implications
Phthalates (i.e., dimethyl phthalate, diethyl phthalate, di-n-butyl phthalate, butylbenzyl phthalate, bis(2-ethylhexyl) phthalate, di-n-octyl phthalate)	Not reported if present in the method blank.	Include analyte if concentration is greater than 10X blank. Exclude analyte in all other situations.
Solvent preservatives (i.e., cyclohexanone, cyclohexenone, cyclohexanol, cyclohexenol, chlorocyclohexene, chlorocyclohexanol)	Not reported if present in the method blank.	Exclude if hexane concentration not 10X method blank. Exclude if hexane concentration not 10X field blank (EPA definition). Exclude if sample not analyzed within 7 days.
Aldol reaction products of acetone (i.e., 4-hydroxy-4-methyl-2-pentanone, 4-methyl-penten-2-one, 5,5-dimethyl-2(5H)-furanone)	Not reported if present in the method blank.	Include analyte if concentration is greater than 10X blank. Include analyte if concentration is less than 10X greater than blank concentration and mutiple ketones are detected. Exclude analyte in all other situations.

*U.S. Government Printing Office: 1990-748-159/20500